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Continuing patent applications at the USPTO

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Abstract

Despite their growing importance for firm innovation strategy and frequent appearance in U.S. patent policy debates, how continuing patent applications are used remains unclear. Turn-of-the-century reforms strongly limited opportunities to extend patent term and surprise competitors, but continuing applications have steadily risen since. We argue that they retain a subtle use, as applicants can file continuations to keep prosecution open and change patent scope after locking in gains with the initial patent. We document a sharp drop in parent abandonment and rise in continuations per original patent after the reforms. Continuing applications are more privately valuable than original patents, are filed in more uncertain contexts, for higher value technologies, by more strategic applicants, and react strongly to the notice of allowance. The evidence supports a current strategic use of continuing applications to craft claims over time.

JEL Codes: O31; O34; O38
Keywords: intellectual property, patent scope, continuation, divisional, innovation

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1 Introduction

An important feature of the U.S. patent system is that the United States Patent and Trademark Office (USPTO) cannot finally grant or reject a patent application. Inventors can file child applications called *continuing applications* that prolong the examination of the parent application beyond its disposal and comprised 20% of the almost 600,000 utility patent (henceforth, 'patent') filings at the USPTO in 2018 (Cotropia and Quillen Jr, 2019). Among continuing applications, continuations (CONs) contain claims on the same invention disclosed in their parent, continuations-in-part (CIPs) additionally disclose new matter, and divisionals (DIVs) are filed when the original filing contains multiple inventions. In theory, continuing applications help applicants deal with technological, commercial, legal, or examination uncertainty by delaying claim drafting, but they have also been linked to opportunistic behavior, litigation, the large USPTO backlog, and overlapping intellectual property rights creating barriers for competitors.[1]

Continuing applications' costs and benefits are often discussed in public policy debates. Patent attorneys, patentees, investors, and industry associations emphasize that continuing applications enable research-intensive organizations, startups, and innovators in industries characterized by long lags between invention and commercialization to appropriate the returns to their inventions. Conversely, the U.S. Federal Trade Commission has expressed its concerns about opportunistic uses of continuing applications (FTC, 2003, 2011). USPTO Director Dudas criticized the practice for the additional work it imposes on the patent office in 2005 and in 2007 the USPTO proposed new rules to significantly limit it – without success. In 2021, the Food and Drug Administration (FDA) expressed concerns about continuations' role in creating overlapping intellectual property rights that delay generic drug approval.[2]

[1] Frakes and Wasserman (2015); Graham (2004); Graham and Mowery (2004); Hegde et al. (2009); Lemley and Moore (2004); Lemley and Shapiro (2005); Quillen et al. (2002); Righi (2022); Righi and Simcoe (2022).

[2] Comments to the rule changes proposed by the USPTO in 2007 provide examples of different opinions on continuing applications: https://www.uspto.gov/patent/laws-and-regulations/comments-public/comments-regarding-continuation-practice (accessed May 8, 2020). Jon W. Dudas' testimony before the U.S. Senate is available at https://www.judiciary.senate.gov/imo/media/doc/Dudas%20Testimony%20042505.pdf (accessed June 16, 2020); the FDA's letter to the USPTO is available at https://www.fda.

Despite their importance for firm patenting strategies and frequent, controversial appearances in policy debates, it is unclear *how* continuing applications are currently used. Prior evidence mostly relies on data produced before two important reforms significantly altered the U.S. patent system and eliminated the most extreme 'submarine patenting' often associated with continuing applications (Graham, 2004; Graham and Mowery, 2004; Hegde et al., 2009; Lemley and Moore, 2004). When applications were not published and patents expired 17 years after the grant date, applicants would combine secrecy and delays in claim drafting by abandoning the parent filing and using continuations to amend claims to cover competitors' new products, exposing competitors who had made technology-specific investments to a hold-up situation and surprising them with licensing fee requests and litigation threats. The agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) limited patent protection to 20 years following the original filing date and the American Inventors Protection Act (AIPA) required applications to become public 18 months after the original filing date, eliminating the most egregious abuses. Continuing applications fell sharply after these reforms, but have since strongly rebounded (Figure 1).[3] In this paper, we study how continuing applications are employed within this new institutional setting.

To guide our investigation, we note that continuing applications retain their strategic potential after TRIPS and AIPA, but operate more subtly (Glazier, 2003; Graham and Mowery, 2004; Lemley and Moore, 2004). Even under different public application and patent term rules, continuing applications help applicants craft claims over time and obtain valuable patent rights by providing opportunities to deal with technological and commercial uncertainty, tailor claims to particular invention embodiments, or cover arguments brought up by possible infringers during litigation. We build on this idea to reason about implications for parent abandonment, number of continuations per original patent, private patent value, links to parent filing attributes (including higher *ex ante* value), and office actions.

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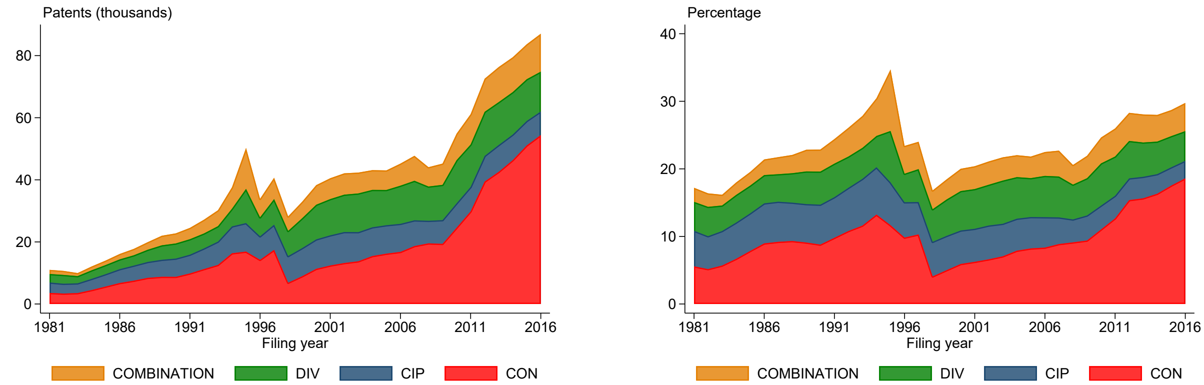
gov/media/152086/download (accessed September 14, 2021).

[3] For this reason, the USPTO's Patent Public Advisory Committee recommended further study of the continuing applications' causes and consequences in its 2020 report, available at https://www.uspto.gov/sites/default/files/documents/PPAC_2020_Annual_Report.pdf (accessed December 24, 2020).

Figure 1: Patents from continuing applications by filing year



(A) Patents

(B) Percentage

Notes. Panel A plots the number of patents that issue from continuing applications by filing year. Panel B plots the percentage of patents that issue from continuing application by filing year. The sample contains patents granted between 1981 and 2020, filed between 1981 and 2016. We exclude reissues.

We find a sharp drop in parent application abandonment for CONs and a significant rise in CON child patents per original patent after TRIPS, providing *prima facie* evidence for shifts in their use. We also document that continuing application patents have higher private value than original patents: they are more likely to be renewed, litigated, reassigned, used as collateral, licensed, used to protect drugs listed in the Orange Book, or declared essential for information and communication technology (ICT) standards; according to most measures, they are also more valuable than their own parents. Filing a continuing application is *ceteris paribus* positively associated with proxies for expected value (number of independent claims, international patent family size, provisional applications) and links to science. Applications assigned to intellectual property-producing patent assertion entities (IPAEs) generate higher rates of CONs and CIPs; foreign applicants are less likely to file continuing applications, such that prosecution process mastery is likely required for continuation-based strategies. Small entities are more (less) likely to use CIPs (CONs and DIVs), as could be expected for novel subject matter triggering technical improvements.

A crucial and novel part of our analysis concerns office actions: rejections have only muted associations with the probability of filing continuing applications, but the notice of allowance is followed by a sizable jump in the probability of filing child applications, especially for patents building on science, where technology uncertainty is high, and applications assigned to IPAEs, where strategic behavior is most expected. Coupled with our final finding that continuing applications have a mixed and low-magnitude association with claim narrowing during prosecution, our evidence suggests that applicants mainly use continuing applications to expand or tailor claim scope after locking in gains with an initial patent.

Our paper makes several contributions to the innovation literature. We highlight the shift in continuing applications' use from combining delays and secrecy without losing patent term, erecting defensive barriers, and protecting pioneering inventions (Graham, 2004; Graham and Mowery, 2004; Hegde et al., 2009) to keeping prosecution open and modifying patent boundaries after first patent issuance. We show that continuing applications represent an important instrument for applicants to change the scope of protection on an invention, contrary to the idea that they are used to react to claim narrowing during examination. In doing so, we add to work on patent scope (Kuhn, 2016; Kuhn and Thompson, 2019; Marco et al., 2019) and prosecution duration (Hegde et al., 2022), and complement work on continuations' use to patent technology developed after the original patent filing date (Righi and Simcoe, 2022). The benefits of prolonged prosecution are visible in continuing applications' private value (Bessen, 2008; Gambardella et al., 2008; Harhoff et al., 2003); this contrasts with results based on citations (Hegde et al., 2009), which may induce measurement error (Katznelson, 2007; Younge and Kuhn, 2016; Kuhn et al., 2020) and capture distinct value dimensions, like knowledge spillovers and cumulative innovation (Hall et al., 2001; Galasso and Schankerman, 2015); understanding continuing applications' social value thus remains important. We also highlight IPAEs as heavy users of continuing applications, complementing work on patent assertion entity purchases and litigation (Cohen et al., 2019; Feng and Jaravel, 2020; Orsatti and Sterzi, 2019). Our findings open questions about alternative tools for delaying claim drafting (Berger et al., 2012; Harhoff, 2016), with patent system design implications, and we trace out empirical suggestions for researchers using patent data for measuring inventive activity to deal with biases arising from continuing applications.

2 Theoretical framework

2.1 Continuing applications

A distinguishing feature of USPTO patent prosecution is that an inventor can file a continuing (child) application of an original application at any point during the parent's pendency, and even after parent disposal if another child application is pending (35 U.S. Code § 120). Continuations (CONs), the most widespread type, contain new claims only on the invention disclosed in their parent application, while continuations-in-part (CIPs) contain claims on both the invention disclosed in their parent application and on new subject matter. When a patent application discloses more than one invention, the applicant must elect one for the prosecution of the original filing and can then seek protection for any remaining invention(s) by filing divisionals (DIVs) voluntarily or as a result of the examiner's decision to issue a restriction requirement (35 U.S. Code § 121). Unlike CONs and CIPs, DIVs are available in other patent systems, including at the European Patent Office.

Crucially, continuing applications benefit from their parent application's priority date: patent examiners consider only the prior art available at the parent's priority date when evaluating claims in CONs and DIVs, or those in CIPs supported by the original disclosure. Moreover, there is no limit on how many continuing applications can be filed per original filing and the fee for processing a continuing application is the same as for an original application. These features together create incentives to use continuing applications strategically, as we show below. The different types provide similar advantages, so we refer to them as a single category in most of our discussion, although we occasionally note differences. In brief, all CONs, CIPs, and DIVs enable higher flexibility in claim drafting; the original application must disclose the invention claimed in CONs and DIVs, while an applicant has to use CIPs to disclose additional subject matter. DIVs are the usual response to restriction requirements on broad applications that claim more than one invention, but patent applicants can also file 'voluntary DIVs' that provide the same legal benefits as CONs and, to the best of our knowledge, there is no active monitoring of proper application labeling.

2.2 Uses of continuing applications

An important consideration for permitting continuing applications is to help inventors deal with uncertainty. When they have better understood their technology, refined it, or identified its most promising commercial applications, inventors can exploit continuing applications to draft new claims. This flexibility is particularly important in industries characterized by higher uncertainty about an invention's economic value in the early stages of development and long lags between invention and product launch, such as pharmaceuticals and biotechnology (Allison and Lemley, 2000; Lemley and Moore, 2004; Hegde et al., 2009).

The value of addressing commercial and technological uncertainty may be especially high for start-ups, since continuing applications allow them to obtain a first patent on their inventions and attract investors (Farre-Mensa et al., 2020; Gaulé, 2018), with the option to broaden or refine patent protection later. For startups and research-intensive organizations, a patent may also be required to enter into licensing agreements with owners of relevant complementary assets for bringing the technology to market (Gans et al., 2008). Continuing applications may then facilitate licensing through the possibility of amending patent scope according to potential licensees' needs even after the issuance of a first patent.[4]

Continuing applications also help applicants interact with the patent office. First, inventors can employ them to draft new claims that work around or exploit changes in patent law or court decisions occurring after the allowance of the original patent. Second, examiners sometimes require applicants to submit data supporting specific claims, but these data may not have existed at the original filing time, as they are often produced during technology development. Continuing applications (especially CIPs) facilitate applicants' ability to respond to such requests.[5] Third, applicants can use continuing applications to amend claims

[4]See comments on the USPTO proposed changes to the continuation practice by Biotechnology Industry Organization (https://www.uspto.gov/sites/default/files/documents/fpp_continuation_bio.pdf), Wisconsin Alumni Research Foundation (https://www.uspto.gov/sites/default/files/documents/fpp_continuation_warf.pdf) and Burnham Institute for Medical Research (https://www.uspto.gov/sites/default/files/documents/fpp_continuation_dunbar.pdf) (accessed June 10, 2020).

[5]See comments by the Pharmaceutical Research and Manufacturers of America (https://www.uspto.gov/sites/default/files/documents/fpp_continuation_phrma_con.pdf) (accessed June 10, 2020).

in response to prior art discovered after the original filing (Lampe, 2012).

By helping address uncertainty, continuing applications increase the appropriability of returns to inventive activities and could be not only privately, but also socially valuable if they stimulate innovation investments, early invention disclosure, and technology commercialization. However, their benefits must be compared with their costs. The continuation practice increases uncertainty in patent boundaries, raises cumulative innovation costs, and opens the door for opportunistic behavior with regards to both patent office and competitors, raising questions of possible abuses of the system.

In theory, continuing applications can aid the 'back-and-forth' examination process, but a practical concern is that inventors can use them to obtain claims previously rejected or broader than those obtained initially. This imposes additional work on time-constrained patent examiners on already-reviewed subject matter to the detriment of new applications, at the risk of exacerbating the USPTO's persistent backlog problem and possibly leading to 'bad patent' issuance (Quillen and Webster, 2001; Frakes and Wasserman, 2015; Lemley and Moore, 2004; Cotropia and Quillen Jr, 2019).[6] Though child applications are usually assigned to their parent's examiner, applicants may also hope a continuing application is assigned to a different, possibly more lenient examiner (Lemley and Moore, 2004).[7]

Continuing applications help inventors deal with uncertainty, but generate patent scope uncertainty that may be detrimental to other parties. The ability to draft new claims later in prosecution decreases the effectiveness of competitors' investments to invent around patents, as inventors can revoke from the public domain what other parties considered freely available.

[6] This does not mean that patents granted by the USPTO are low quality on average or that higher grant rates are necessarily bad. In fact, examiners become more efficient with experience and seniority, and higher grant rates of more senior examiners are associated with a more intense use of examiner amendments that reduce processing time without impacting patent quality (deGrazia et al., 2021). The 'wear-down the examiner' argument simply builds on the idea that examiners can only finally dispose of an application by allowing it. This incentivizes persistent applicants to file chains of continuations until they obtain the claims they want, and can eventually lead to the grant of overly-broad claims. Moreover, while continuations may be easier to process than original filings because the examiner usually reviewed the parent application, the patent office may prefer to allocate scarce examination resources to new filings, as Dudas' testimony before the U.S. Senate (footnote 2) and the USPTO's attempt to limit the continuation practice suggest.

[7] In our post-AIPA data, 27% of continuing applications are assigned to a different examiner.

This generates hold-up problems for inventors who make technology-specific investments under the assumption they are not infringing any IP and are later surprised with licensing fee requests and litigation threats for infringing claims written long after the original disclosure. This problem is exacerbated in complex technology areas defined by overlapping intellectual property rights and royalty stacking, such as ICT industries, where innovators need to license patents from multiple parties (Lemley and Shapiro, 2007; Shapiro, 2001).[8]

Historically, this hold-up problem was particularly serious when continuing applications were deployed within 'submarine patenting' strategies (Graham and Mowery, 2004). Patents expired 17 years after grant date prior to the 1995 TRIPS agreement and patent applications were not published before AIPA came into effect in 2000. Patentees could thus surprise competitors with patents issued after a long patent office pendency by filing chains of continuing applications tailored to cover developments in the marketplace without losing patent term and abandoning previous filings to avoid disclosure. However, TRIPS and AIPA eliminated the most extreme forms of submarine patenting by shortening the patent term for patents with a long pendency (patent protection generally ends 20 years after the original filing date for post-TRIPS patents) and requiring the publication of applications 18 months after the original filing date (despite some exceptions, the vast majority of post-AIPA applications are published before grant, Graham and Hegde, 2015). In general, filing continuing applications became less convenient and their use dropped substantially (Figure 1).

Nonetheless, uses of 'submarine claims' remain available after TRIPS and AIPA (Glazier, 2003). Application publication increases knowledge diffusion (Baruffaldi and Simeth, 2020; Hegde and Luo, 2018), but it is often hard to predict all the possible claims supported by an invention's disclosure because the written description is often ambiguous, opaque, and does not provide enough technical information (Chiang, 2010; Roin, 2005; Seymore, 2009). As unexpected claims can still 'surface', patent scope uncertainty can last until the end of the patent term if applicants file long chains of continuing applications. In practice, patentees

[8] See also Intel's comments on the proposed USPTO rule changes (https://www.uspto.gov/sites/default/files/documents/fpp_continuation_intel.pdf) (Accessed June 18 2020).

can use child applications to tailor claims to a specific device and then assert them, or even draft new claims responding to arguments made during litigation by alleged infringers.

Righi and Simcoe (2022) document an example of strategic continuation use to draft claims covering technology developed after the original patent filing date. Exploiting features of the ICT standardization process, they show that standard publication – an observable proxy for the resolution of technology design uncertainty – leads to a rise in continuations of patents declared essential for the focal standard relative to a matched control sample. These continuations are then more likely to be litigated, illustrating how the process of crafting claims over time is an important part of firms' patenting strategy.

The shift toward subtler uses of late claim drafting likely drives the rebound in continuing applications after their late 1990s slump. As more firms recognized the value of intellectual property for firm strategy (Rivette and Kline, 2000) and inventors gradually adjusted to the new institutional setting, patentees likely directed their efforts towards broadening the scope of already-granted patents by prolonging their prosecution, carefully crafting claims over time with the goal of creating barriers for competitors. In this case, we would expect a rise in the number of continuations per patent, while the rate of parent abandonment should drop considerably – precisely what our data show (Section 3.1). In this strategy, as we argue below, continuing applications should also be responsive to the allowance of claims in the parent application; indeed, this is what we find (Section 4.3).

2.3 Private value

If continuing applications are filed strategically to craft claims, this practice should create value for patentees even if submarine patenting is no longer possible. Moreover, applicants still have stronger incentives to invest in continuing applications for their more valuable inventions. We would therefore expect to observe positive correlations between continuing applications and several distinct measures of private value.

Hegde et al. (2009) show that – prior to AIPA – patents from CONs and DIVs receive, *ceteris paribus*, a lower number of patent citations than those from original applications, while patents from CIPs receive more. They interpret these findings as evidence that firms use CIPs for inventions with higher technological importance, and CONs and DIVs for less important inventions. However, Katznelson (2007) argues that patent citations underestimate child patents' importance. The disclosure in CONs and DIVs is usually identical to that in the parent application (Younge and Kuhn, 2016) and patent examiners, responsible for a large share of patent citations (Alcacer and Gittelman, 2006; Alcacer et al., 2009), often cite the earliest prior art document – the original filing – when rejecting claims on a given disclosure. We therefore focus on alternative proxies.

First, keeping a patent in force requires patentees to pay maintenance fees 4, 8, and 12 years after grant date. Under the reasonable assumption that patentees pay these fees only if the private value of patent renewal exceeds its costs, fee payment is often used to estimate a lower bound on patents' private value (Lanjouw, 1998; Lanjouw et al., 1998; Pakes, 1986). If patents from continuing applications are more valuable than original patents, we should expect a positive correlation with patent renewal.

Second, litigated patents are generally considered valuable because they protect higher-value inventions, are broader, or are stronger (Allison et al., 2004); indeed, Bessen (2008) finds that litigation is strongly associated with economic value. As we note above, patentees can use continuing applications to increase other parties' likelihood of infringement, leading to more disputes. We expect continuing applications to have higher litigation rates than original patents, a result Marco and Miller (2019) and Righi (2022) also document.

Third, involvement in market transactions – patent trades and licensing – positively correlates with other patent value measures (Kuhn, 2016; Serrano, 2010; Gambardella et al., 2007). Moreover, inventors and innovative companies may collateralize patents to secure financing (Hochberg et al., 2018). If patents from continuing applications are more valuable than original patents, we should expect a positive correlation with such transactions.

Fourth, we exploit institutions in two areas to link patents with important technologies. In pharmaceuticals, the Orange Book lists patents that protect drugs approved by the FDA. Given the importance of patents in this industry, they are likely to be high-value patents. In ICT, Standard Setting Organizations often require their members to disclose patents likely to be essential for a standard's implementation. Standard-essential patents are more valuable than comparable non-standard-essential ones, and their ownership correlates positively with financial performance (Bekkers et al., 2017; Hussinger and Schwiebacher, 2015; Pohlmann et al., 2016; Rysman and Simcoe, 2008). If continuing applications help applicants refine claims to improve fit with their products and build barriers around important technologies, we would expect them to be included in the Orange Book (in pharmaceuticals) or declared standard essential (in ICT) at higher rates.

2.4 Parent attributes

To better understand the role of continuing applications within patenting strategies, we also analyze the link between their use and original applications' attributes. While our arguments suggest that continuing applications are positively correlated with patent value, the proxies discussed in Section 2.3 are either only available for granted patents or selected subsamples, or possibly influenced by the examination process. To more closely link continuing applications with an invention's *ex ante* value, we analyze an additional proxy for value generally available for all applications, including those abandoned, and unaffected by examination: international patent family size. The underlying logic is that inventors bear additional costs for filing in each new jurisdiction, so the number of jurisdictions in a family should positively correlate with a given invention' expected returns. This idea has received empirical support (Harhoff et al., 2003; Lanjouw et al., 1998; Putnam, 1996). Longer domestic prosecution also requires additional expenses, so we expect continuing applications to be used more often for higher-value inventions, i.e. those with a larger international family size.

As continuing applications help adjust patent scope over time, it is important to understand how the original application's scope is associated with their use. This relationship is theoretically ambiguous. On the one hand, an original application with broad scope may be positively correlated with the economic value of the invention. Those with a large number of claims may also cover multiple inventions, so we expect this dimension of breadth to be strongly associated with DIV, rather than CON or CIP filing. As broader applications experience a more intense examination (Marco et al., 2019), applicants may also use continuing applications to obtain initially rejected claims or broader claims than those allowed with the first patent (we return to this in our empirical analysis in Section 4.4). On the other hand, the patent office processes narrower applications faster, so applicants wishing to obtain a patent relatively quickly may start with a narrower original filing (with fewer or narrower claims) and seek broader scope later through continuing applications.

Inventions building intensively on science are likely to experience higher technological and commercial uncertainty in their initial development stages, as well as a longer lag between invention and commercialization. This creates stronger incentives to delay claim drafting, so we expect patents heavily reliant on science to produce more continuing applications.

Another way for inventors to establish priority but delay claim drafting (for 12 months) is to file a provisional application, which does not require specifying claims (35 U.S. Code § 111). It is unclear whether their use hinders or fosters continuing applications. If provisionals substitute for other mechanisms to delay claim drafting, this relationship may be negative; but a positive one emerges if provisionals are filed by sophisticated applicants for more valuable inventions, factors that also favor continuing applications.

Applicant identity also matters, in both the nature of inventions they produce and their ability to interact with the patent office. As comments to the USPTO rule changes suggest, continuing applications may be important tools for startups and small research-intensive organizations. Large organizations often rely on CONs and DIVs to build large patent portfolios for defensive purposes (Hegde et al., 2009), but small research-intensive entities may disclose more novel subject matter that subsequently triggers a string of related technical improvements, leading to more intensive CIP use. Moreover, small entities often lack experience and sophistication in drafting patents or interacting with the patent office and may file CIPs at a higher rate to correct mistakes in patent drafting and disclose additional matter. Foreign applicants' lower familiarity with the system's more subtle features may also hinder strategic patent office interactions, so we expect their original filings to have lower rates of continuing applications of all types.

By contrast, some applicants likely deploy substantial sophistication in interacting with the patent office. A particular type of applicant with strong incentives to delay claim drafting to achieve advantages in patent licensing and assertion are IP-producing Patent Assertion Entities (IPAEs). Rather than assert patents acquired from other organizations and inventors (Feng and Jaravel, 2020; Orsatti and Sterzi, 2019; Cohen et al., 2019), IPAEs organize their business model around filing and prosecuting their own patent applications; they include non-practicing entities such as pure upstream technology developers and companies purposely started by individual inventors that generate revenues through IP licensing and litigation. For instance, Righi and Simcoe (2022) describe how technology developers Rambus and Wi-LAN used continuations to cover ICT standards' technical advancements. Another example involves Rothschild Connected Devices Innovations LLC, a non-practicing entity founded by inventor Leigh M. Rothschild. In 2006, this company filed a patent describing a process for making custom orders over the Internet; after a first patent was granted in 2011, the firm obtained a continuation with broad claims in 2014 and proceeded to litigate alleged infringers.[9] Given strong incentives to exploit the prosecution process and obtain IP assertion advantages, we expect IPAEs' applications to have higher child application rates.

2.5 Office actions

Continuing applications can be filed at any time during their parent application's examination, so analyzing their timing can yield significant insights. If child applications are simply

[9] This IPAE example is described in detail at https://www.eff.org/deeplinks/2015/08/stupid-patent-month-drink-mixer-attacks-internet-things (accessed October 5, 2020).

tools to have another chance to obtain rejected claims, rejections should spur continuing applications; but if they are used strategically to deal with uncertainty and prolong prosecution, we would expect continuing applications to be filed more often when an inventor has obtained a first patent. We elaborate on these ideas below.

Patent examination is often described as a 'back and forth' negotiation between inventor and examiner, marked by several pivotal moments (for details and statistics, see Cockburn et al., 2002; Carley et al., 2015). After a review of legal formalities and requirements, a patent examiner assesses whether the claimed invention involves patentable subject matter and is sufficiently described and enabled, and compares it to the prior art to determine whether it is novel, non-obvious, and useful. If the application satisfies these criteria, the examiner issues a 'notice of allowance' accepting the claims. However, a more frequent outcome is for them to issue a 'non-final rejection' that rejects some claims based on prior art similarity or insufficient invention description. Applicants normally respond to this rejection (amending claims or arguing for the original ones) and the examiner reviews the response. The examiner can then allow the claims or reject them and issue a 'final rejection'; yet, this outcome does not end prosecution, as multiple options remain available to the applicant.

Several studies consider continuing applications to be an important avenue for inventors to respond to rejections (Lemley and Moore, 2004; Hegde et al., 2009), since they can be used to reopen prosecution for the originally disclosed subject matter. However, they are not the only recourse available. Applicants may simply amend claims following rejection (including when examiners withdraw their final rejection after an interview), file a request for continued examination, or appeal the examiner's decision. We thus expect the relationship between non-final and final rejections and child applications to be relatively muted.

The notice of allowance may play a significant role instead, because inventors can lock in the advantages obtained with the issuance of a first set of claims while leaving open the option to draft new claims with continuing applications. Following a notice of allowance, applicants have three months to pay the issuance fee. If they do not reopen prosecution because they are dissatisfied with the claims allowed (typically, with a request for continued examination), patents generally issue within one month from the payment of the issuance fee, unless the Office accepts a petition to defer issuance or there are extraordinary circumstances.[10] Prior to issuance, patent applicants can file a continuing application, so they can continue to monitor legal, technological, commercial, or competitive developments and alter claims over time after obtaining patent protection. We therefore expect continuing applications – CONs, CIPs, as well as DIVs, which can also be filed voluntarily – to be filed at high rates following the notice of allowance.

Heterogeneity in responsiveness to the notice of allowance can be informative about child applications' strategic value. We focus on two application attributes linked to a higher value of delays in claim drafting: patents' reliance on science and whether the applicants' business model directly relies on patent assertion. The higher uncertainty surrounding science-based patents and longer invention-commercialization lag increase incentives to keep prosecution open after initial gains have been locked in, so we expect such applications to generate more child applications after a notice of allowance. The value of prolonging prosecution should also be larger for IPAEs given their strong incentives to invest in obtaining high-value claims that they can license or tailoring claims to prepare for litigation, so we expect these firms to file child applications at higher rates following a notice of allowance.

Among continuing applications, we expect CIPs to be relatively less reactive to office actions because patentees need to weigh the strategic advantages of delayed claim drafting with the incentives to establish priority for newly disclosed subject matter, whereas CONs and DIVs contain only claims that benefit from the parent filing's priority.

When the subject matter disclosed in the original patent application covers more than one invention the examiner may issue a 'restriction requirement'. At this stage, applicants must restrict the first application's claims to a single invention and can pursue remaining claims via a DIV. Although DIVs can be filed voluntarily at any stage of the parent appli-

[10]See https://www.uspto.gov/web/offices/pac/mpep/s1306.html (accessed October 23, 2022).

cation's prosecution – becoming practically indistinguishable from CONs –, the restriction requirement naturally triggers an increase in the likelihood of DIV filing.

3 Data and methods

3.1 Data sources and variables

Understanding the use of continuing applications requires a substantial data collection effort. Our main source on applications and their prosecution is the Patent Examination Research Dataset (PatEx) 2020 release (Graham et al., 2018a). For additional application attributes, we match PatEx with the Patent Claims Research Dataset (Marco et al., 2019), Patent Assignment Dataset 2021 release (Graham et al., 2018b), Reliance on Science in Patenting Dataset version v36 (Marx and Fuegi, 2020, 2022), Searle Center Database on Technology Standards (Baron and Gupta, 2018; Baron and Pohlmann, 2018; Baron and Spulber, 2018), U.S. FDA Orange Book,[11] Stanford NPE Litigation Dataset (Miller, 2018), PATSTAT Fall 2014 release, USPTO patent maintenance fee events data,[12] Lex Machina, and RECAP.

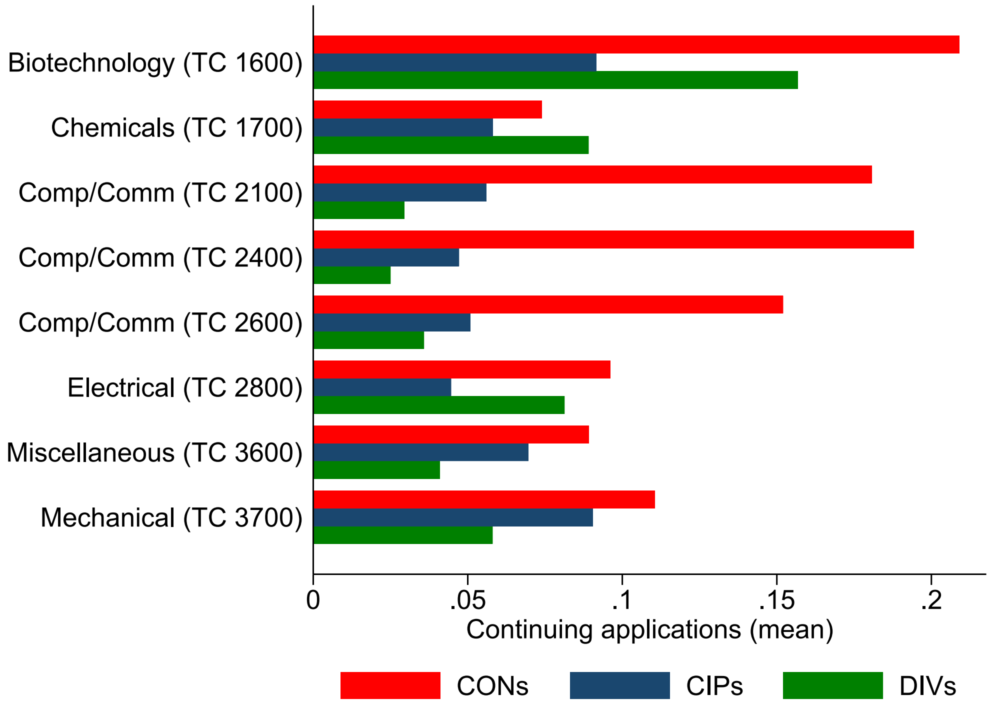
The main analysis sample contains all original patent applications in PatEx filed between November 29, 2000, when AIPA's publication requirement came into effect, and the end of 2018.[13] Our sample contains about 4.6 million applications; summary statistics are available in Online Appendix Table A1 and Figure A1 plots their distribution by technology center. Most applications do not have any continuing applications and the average number of child patents per original filing is low (0.12 CONs, 0.06 CIPs, and 0.07 DIVs), but some applications have hundreds of continuing applications. An interesting and, to our knowledge, novel result emerging from our data is the significant use of voluntary DIVs: 22% of applications that generate a DIV do not receive a restriction requirement by the end of 2018, a distinction

[11]Orange Book data are publicly available at https://heidi-williams.humsci.stanford.edu/data (accessed June 19 2020). We thank Heidi Williams for sharing these data.

[12]Data downloaded on June 28 2022 from the USPTO, see https://developer.uspto.gov/product/patent-maintenance-fee-events-and-description-files.

[13]Original applications are non-provisional patent applications that are not reissues of previous patents, reexaminations, or continuing applications of another filing. The 2020 release of PatEx covers filing activity through April 2021, but we discard data after 2018 to minimize publication lag concerns.

Figure 2: Continuing applications by technology center



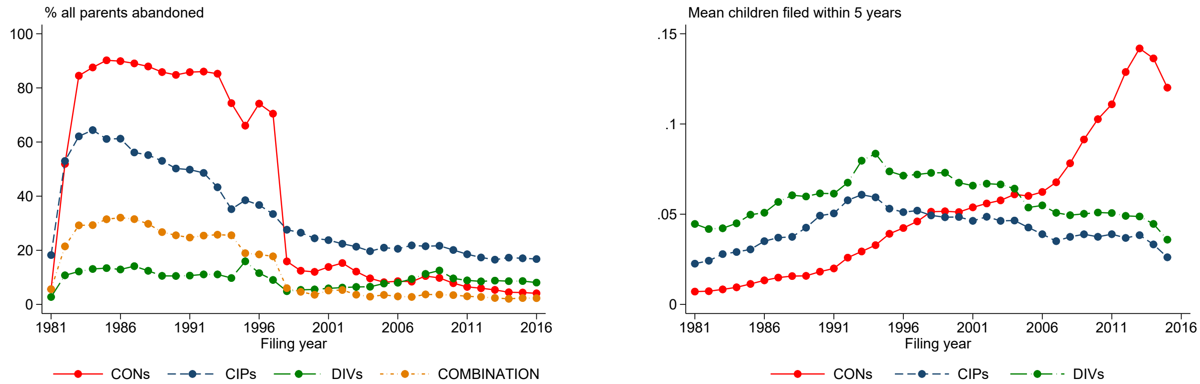
Notes. The figure plots the mean number of CONs, CIPs, and DIVs filed before the end of 2018 per original filing by USPTO Technology Center. These include 'Biotechnology' (TC 1600), 'Chemical and Materials Engineering' (TC 1700), 'Computer Architecture, Software, and Information Security' (TC 2100), 'Computer Networks, Multiplex Communication, Video Distribution and Security' (TC 2400), 'Communications' (TC 2600), 'Semiconductors, Electrical and Optical Systems and Components' (TC 2800), 'Transportation, Construction, Electronic Commerce, Agriculture, National Security and License & Review' (TC 3600), and Mechanical Engineering, Manufacturing, Products' (TC 3700) (Miller, 2020). We label TC 2100, 2400, and 2600 'Computers/Communications' as in Graham et al. (2018a). The sample is our main analysis sample.

we consider in Section 4.4. The probabilities of filing child applications are much higher after a notice of allowance than after any other office action (Table A2).[14]

Our data allows us to update the evidence on the use of continuing applications across technology areas. Figure 2 displays the number of CONs, CIPs, and DIVs filed per original application by USPTO technology center. Despite differences in sample and unit of analysis, our results match those in prior work (Lemley and Moore, 2004; Hegde et al., 2009). Applications in biotechnology – where patents likely build on science and commercialization lags are relatively long – have the highest number of continuing applications. Applications in

[14] Righi and Simcoe (2022) report similar statistics for their sample of standard essential patents.

Figure 3: Parent abandonment and child patents



(A) Parent abandonment (B) Number of children

Notes. Panel A plots the percentage of patents issuing from continuing applications whose parent applications are all abandoned by filing year. Panel B plots the mean of child patents filed within five years of the original filing date for patents that issue from original applications by filing year. The sample contains patents granted between 1981 and 2020, filed between 1981 and 2016 in Panel A and filed between 1981 and 2015 in Panel B.

computers and communications also display a large number of CONs, likely due to strategic uses in important technology areas such as ICT standards (Righi and Simcoe, 2022).

Focusing on the sample of patents issued before 2021 and adding data on the pre-AIPA period, we provide two novel results on continuing application use in Figure 3. Panel A plots the share of patents from continuing applications that have all their parent applications abandoned, by filing year. Before TRIPS, up to 90% of patents from CONs have all their parents abandoned; this share falls drastically to less than 20% soon after TRIPS and more gradually afterwards. The share of CIPs and DIVs with all parents abandoned also falls over time, but at a slower pace. In Panel B, patents from original applications display, on average, a steadily rising number of child patents issuing from CONs (within 5 years of the original filing date).[15] This evidence accords with a shift in continuations' use from seeking to exploit secrecy and extend patent term – often abandoning the parent application – to locking in claims with a first patent, while keeping prosecution open.

For our main analysis we compute measures of private value, parent attributes, office actions, and scope narrowing during prosecution. We capture patent *renewal* via the payment

[15] Results are similar with a 10-year threshold and suggest that the small decrease at the end of the sample period is likely due to truncation.

of the first maintenance fee 4 years post-grant (and use similar 8- and 12-year measures in robustness checks). We identify patents *litigated* at least once in a district court from 2000 to 2018 using Lex Machina data. A patent is traded if it is *reassigned* after its first assignment from inventor to employer or *licensed* to another entity (limited to patents filed before 2005 and assigned to the biotechnology technology center in our RECAP data);[16] we also observe if a patent is used as *collateral* for a loan (Hochberg et al., 2018). For biotech patents granted before 2017, we note their inclusion in the *Orange Book*; for computers and communications patents filed before 2016, we note if they are declared *standard essential*.

Using PATSTAT data, we measure international patent *family size* as the number of unique non-U.S. jurisdictions in the DOCDB family (Martinez, 2010) within one year from the U.S. patent filing. We use two measures of patent scope (Feng and Jaravel, 2020; Kuhn and Thompson, 2019; Marco et al., 2019). A larger *number of independent claims* usually provides broader scope because each claim describes a different invention embodiment or use; the *number of words per independent claim* captures the idea that longer claims usually provide narrower scope, as every word added introduces additional elements that must be present to establish infringement. We use patent citations to scientific publications from the Reliance on Science in Patenting data to identify (granted) patents building on *science* (Arora et al., 2017; Belenzon and Schankerman, 2013; Bikard and Marx, 2019; Roach and Cohen, 2013). We use the Stanford NPE Litigation Dataset and employee-employer assignments in the Patent Assignment Dataset to create an indicator equal to one for applications assigned before disposal by the inventors to *IPAEs*.[17] Our PatEx data directly provide priority claims to *provisional* applications and *foreign* patents, and record which applications are *national*

[16] To exclude re-assignments within the same organization, we clean and standardize assignor and assignee names, and consider a patent as traded if the Jaro-Winkler distance between these names exceeds 0.2. Using the classification provided by Graham et al. (2018b), we exclude transactions related to mergers, security interest agreements, security releases by the creditor, government interest agreements, name changes, corrections, and assignments whose transaction type is missing or difficult to classify.

[17] To identify these applications, we clean, standardize, and match the names of the patent asserters in the Stanford NPE Litigation Dataset and the names of the assignees of the employee-employer assignments in the Patent Assignment Dataset. We classify as IPAEs asserter categories 4 and 5, i.e. firms that switched from being producers to a business model based on patent assertion and companies started by an individual inventor. Details are available upon request.

stage entries of Patent Cooperation Treaty applications or filed by a *small entity* according to the USPTO's official definition – independent inventors, small businesses, and nonprofit organizations.

PatEx also provides the dates of *notices of allowance*, *non-final rejections*, *final rejections*, or *restriction requirements*. For the final step of our analysis, we capture scope narrowing as the *change in the number of independent claims* (the difference between published application and granted patent, so higher values represent more scope narrowing) and the *change in the number of words per independent claim* from the published application to the grant patent (Feng and Jaravel, 2020; Kuhn and Thompson, 2019; Marco et al., 2019).

3.2 Methods

Our empirical analysis proceeds in several steps. In the first step, we study the link between child applications and private value. We estimate linear probability models based on:

$$Y_{if} = \beta_0 + \beta_1 CON_i + \beta_2 CIP_i + \beta_3 DIV_i + \beta_4 Combination_i + X_i\delta + \lambda_f + \varepsilon_{if}, \qquad (1)$$

where i indexes patents, f indexes patent families, and Y_{if} is a binary variable representing one of our proxies for private value; the coefficients on the indicators CON_i, CIP_i, DIV_i, and $Combination_i$ capture differences between patents from continuing applications and original applications; when appropriate, the vector X_i contains filing or grant year effects to control for differences in the time at risk of outcome realization; when we compare child applications with their own parents, we include λ_f patent family fixed effects (Righi, 2022); finally, β_0 is the constant and ε_{if} is the error term (clustered by patent family). We multiply Y_{if}, as well as all binary outcomes in the equations below, by 100 to facilitate coefficient interpretation as percentage-point changes and estimate all models including fixed effects with the estimator described in Correia (2016).

In the second step, we examine how parent attributes are associated with the likelihood of filing a continuing application. For the sample of published original applications for which we have information on claims, we estimate linear probability models based on:

$$Y_i = X_i\beta + \delta_t + \gamma_{ae} + \varepsilon_i, \tag{2}$$

where, depending on the model, Y_i is an indicator equal to one if application i has at least one CON, CIP, or DIV filed before the end of 2018. The vector X_i includes a constant and the parent attributes noted above. We take the natural logarithm of independent claims, words per independent claim, international family size, and references to scientific papers, adding one to the latter two variables to include filings with zeros. We control for differences across cohorts of applications with filing year effects δ_t and for differences across technologies and examiners with art-unit-by-examiner effects γ_{ae}.[18]

In the third step, we build a panel dataset to study the relationship between child application filings and office actions, retaining an original application i in our estimation sample in each calendar quarter t from its filing date to its disposal (either abandonment or grant) or the end of 2018 if it is still pending as of that date. Using this panel, we estimate linear probability models based on:

$$Y_{it} = \beta_0 + \beta_1 NOA_{it} + \beta_2 FR_{it} + \beta_3 NFR_{it} + \beta_4 RR_{it} + \lambda_i + \delta_{at} + \varepsilon_{it}, \tag{3}$$

where Y_{it} is an indicator equal to one if application i has at least one continuing application in quarter t; NOA_{it}, FR_{it}, NFR_{it}, and RR_{it} are indicators that switch once from zero to one if application i receives in quarter t, respectively, the *first* notice of allowance, final rejection, non-final rejection, or restriction requirement; λ_i is a set of application fixed effects that capture time-invariant differences across applications; δ_{at} is a set of calendar-quarter-by-age effects (with age defined as the number of quarters from the filing date) that capture time-varying factors common to all applications, allowing these effects to differ by age of the application; β_0 is the constant, and ε_{it} is the error term. We cluster standard errors at the

[18] Art units are groups of examiners working on similar technologies. Righi and Simcoe (2019) find evidence of technological specialization by patent examiners even within art units. Moreover, previous research shows that examiners differ systematically in their approach to examination (Cockburn et al., 2002; Feng and Jaravel, 2020; Lemley and Sampat, 2012). This may affect applicants' prosecution strategies.

application level. We estimate different models where Y_{it} is computed using information only on CONs, CIPs, or DIVs. When we study office action response heterogeneity, we estimate similar models that include interactions between the notice of allowance and indicators for patents that build on *science* or are filed by *IPAEs*.

To understand the *timing* of child application filings around office actions, we estimate linear probability models based on:

$$Y_{it} = \beta_0 + \sum_{\tau=-12}^{12} \beta_\tau X_{it}^\tau + \varepsilon_{it} \tag{4}$$

where Y_{it} is one of our outcomes, X_{it}^τ is a dummy equal to one if quarter t is τ quarters after the first notice of allowance or restriction requirement for application i, β_0 is a constant, and ε_{it} is the error term. We cluster standard errors at the application level. The β_τ's measure the difference in continuing application filing trends between applications that receive a notice of allowance or restriction requirement and those that do not before (if $\tau < 0$) and after (if $\tau \geq 0$) the office action. We focus on a 25-quarter window (≈6 years) around the relevant office action, using a single indicator if $\tau \leq -12$ and a single indicator if $\tau \geq 12$. In this specification we do not omit any of the X_{it}^τ dummies since some applications never receive a notice of allowance or restriction requirement, so there are no collinearity issues.[19]

In the final step, we study the common view that applicants use continuing applications to respond to claim narrowing during examination. We restrict our analysis to published applications that eventually issue and add our measures of scope change from published application to granted patent (standardized to facilitate interpretation) to Equation 2.

4 Results

4.1 Private value

Table 1 presents our private value results. Comparing patents from continuing applications with original patents in Panel A, the former are, on average, more valuable according to

[19]The X_{it}^τ indicators are set to zero when the relevant office action does not occur.

all our private value proxies. Resulting from a complex priority chain, combinations appear especially valuable across all proxies.[20] Our results differ from those in Hegde et al. (2009), both because citations to continuing applications likely underestimate their value and because our proxies do not capture knowledge spillovers and cumulative innovation in the same way citations do (Hall et al., 2001; Galasso and Schankerman, 2015). Instead, continuing applications generally have higher *private* value and protect important technologies, in line with evidence for their value in specific settings (Righi and Simcoe, 2022; Righi, 2022).

Beyond value-increasing delays in claim drafting, these results may also reflect continuing applications' use for more valuable inventions. To hold constant the underlying invention, we estimate patent family fixed effects models in Table 1, Panel B, comparing patents from continuing applications to those from their parent. As mean outcomes in both panels show, inventions protected by patent families are indeed more valuable. These models' remarkably high R^2 values (models without fixed effects estimated on the same samples have R^2 values close to those in Panel A) suggest that invention characteristics explain a substantial share of variation in outcomes, similar to Righi's (2022) litigation findings. The estimated coefficients suggest that child applications are more likely than their parents to be litigated (except for CIPs), used as collateral, licensed (only weakly), and declared standard essential. We cannot reject the null hypotheses that CONs, CIPs, and combinations are as likely as their parents to be listed in the Orange Book, whereas DIVs are more likely to be included.

However, CONs and DIVs are reassigned less often, likely due to how the USPTO records this information: parent application reassignment gives assignees the rights to subject matter common to its CONs and DIVs, and recordation of the transaction for child applications is unnecessary; this is not the case for CIPs, and indeed we find no reassignment differences with their parent.[21] Child application patents are also less likely to be renewed, a result possibly explained by technology life-cycle and remaining patent life considerations. Renewal dates

[20] Patents from CIPs are less likely to be declared standard essential than original patents, but the essentiality of continuing application patents is underestimated, as patentees often make essentiality declarations and licensing commitments for entire patent families, reporting only the earliest application's patent number.

[21] For technical details, see `https://www.uspto.gov/web/offices/pac/mpep/s306.html`.

Table 1: Continuing applications and private value

Outcome	Renewed (4 years) (1)	Litigated (2)	Reassigned (3)	Collateral (4)	Licensed (5)	Orange Book (6)	Standard essential (7)
Panel A: all patents							
Combination	2.86***	2.90***	13.26***	7.87***	0.45***	1.94***	2.10***
	(0.13)	(0.09)	(0.25)	(0.21)	(0.14)	(0.18)	(0.31)
CON	2.65***	1.26***	6.10***	3.32***	0.22***	2.38***	2.12***
	(0.07)	(0.03)	(0.08)	(0.06)	(0.07)	(0.15)	(0.10)
CIP	2.66***	1.05***	10.56***	6.15***	0.24**	0.64***	-0.35***
	(0.11)	(0.04)	(0.17)	(0.14)	(0.10)	(0.11)	(0.07)
DIV	2.09***	0.20***	2.16***	2.73***	0.09	0.10*	2.40***
	(0.09)	(0.02)	(0.10)	(0.08)	(0.07)	(0.06)	(0.28)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Observations	2,936,043	3,564,485	4,225,947	4,225,947	64,391	223,954	1,016,955
R^2	0.00	0.01	0.02	0.02	0.00	0.01	0.01
Mean outcome	86.57	0.70	17.83	9.75	0.20	1.05	1.58
Mean outcome, original	85.94	0.39	16.30	8.84	0.11	0.52	1.15
Panel B: parent and child applications							
Combination	-7.84***	0.31***	-1.94***	0.37***	-0.43	0.39	1.84***
	(0.15)	(0.09)	(0.20)	(0.13)	(0.91)	(0.28)	(0.23)
CON	-4.56***	0.60***	-0.80***	0.65***	0.43*	0.20	1.16***
	(0.07)	(0.04)	(0.10)	(0.08)	(0.24)	(0.14)	(0.12)
CIP	-3.65***	-0.04	0.00	0.85***	0.20*	-0.05	0.54***
	(0.12)	(0.06)	(0.14)	(0.08)	(0.12)	(0.19)	(0.08)
DIV	-5.56***	0.63***	-1.12***	1.19***	0.25	0.39***	1.68***
	(0.09)	(0.04)	(0.11)	(0.08)	(0.23)	(0.12)	(0.18)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Family effects	✓	✓	✓	✓	✓	✓	✓
Observations	732,190	955,795	1,165,455	1,165,455	8,115	68,937	283,261
R^2	0.68	0.61	0.83	0.90	0.76	0.74	0.78
Mean outcome	90.69	1.19	22.54	13.52	0.21	1.81	2.89
Mean outcome, original	92.81	1.12	23.61	14.35	0.28	1.58	3.14

Notes. All models are estimated with OLS. The unit of observation is the patent. All samples include granted patents from original and continuing applications filed between November 29, 2000 and the end of 2018. The sample for column 1 contains patents issued before 2017 at risk of paying the 4-year maintenance fee. The sample for column 2 contains patents issued before 2019. The sample for column 5 contains patents in biotechnology filed before 2005. The sample for column 6 contains patents in biotechnology issued before 2017. The sample for column 7 contains patents in computers and communications filed before 2016. The samples for Panel B are subsamples of patent families from those for Panel A whose parent patent and at least one child patent are in the sample. Robust standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

are determined by the grant date and patent term by the original filing date, so child patents have a shorter remaining term after renewal than their parents; the protected technology is also older than at their parent's equivalent renewal deadline. The pattern of results matches this intuition: combinations (with typically much longer pendency) have the lowest and CIPs (protecting new subject matter) have the highest renewal probability among child patents.

In the Online Appendix, we obtain similar results for 8- and 12-year renewal (Table A3), except for combinations, which are less likely than original patents to be renewed at the 12^{th} year deadline, probably because of the short remaining useful patent life after the last renewal. We obtain a similar pattern of results for the entire 1981-2018 period (Table A4) and using only pre-AIPA patents (Table A5), although there are differences for some outcomes in the latter estimates.[22] Changes in patenting strategies affecting sample composition likely explain this – the usual parent patent abandonment generates selection into the fixed-effects sample, reducing our ability to compare parent and child patents – and actually suggest child applications' value has increased, another discrepancy with Hegde et al.'s (2009) results.

Overall, our findings suggest that patents from continuing applications are, on average, more privately valuable than original patents and are used for higher-value inventions. They are also broadly valuable relative to parent patents, and although child patents are renewed less than their own parents, they add to the patent portfolio's overall value.

4.2 Parent attributes

Table 2 reports the results of models based on Equation 2, linking original application characteristics to the likelihood of filing child applications. Models 1-3 exclude the international patent family size and references to scientific articles, which are not available for some applications in our sample, but are included in models 4-6 and 7-9, respectively.

Original applications with more independent claims are more likely to generate continuing applications. A 1% increase in this variable is associated to a 0.2-0.3% higher probability of CON or CIP filing relative to the estimation sample mean and a 0.9% ($= 0.01 \times 5.19/5.81$, model 3) higher probability of DIV filing, consistent with the notion that broad applications

[22] Lex Machina data start in 2000, so the litigation analysis including pre-AIPA patents uses data from Thomson Innovation, obtained in April 2016; we therefore only use patents granted prior to 2016.

may cover multiple inventions. By contrast, original applications with longer independent claims have higher odds of generating a continuing application (except in model 7); these relationships' magnitude is small (e.g. a 1% increase in average claim length is associated with a 0.02% increase from the mean in the probability of CON filing, model 1), but aligns with the idea that applicants may begin prosecution with narrower claims to facilitate initial patent grant, only to broaden scope later through child applications.

The benefit of keeping prosecution open is visible especially for higher value technologies and patents building on science. The coefficients for international patent family size (models 4-6) imply a 1% increase in this variable is linked to a 0.5%, 0.3%, and 0.4% higher probability of filing a CON, CIP, and, respectively, DIV relative to the mean. A 1% increase in references to scientific articles (models 7-9) is correlated with increases of 0.2%, 0.3%, and 0.1% relative to the mean for CONs, CIPs, and DIVs, respectively. This evidence supports continuing applications' use for higher-value inventions, as well as in situations where uncertainty is likely to be larger and, consequently, keeping prosecution open is more beneficial.

We observe further evidence that longer prosecution is advantageous for IPAEs: *ceteris paribus*, applications assigned to these entities are 127-150% more likely to file a CON, 104-119% more likely to file a CIP, and 9-22% more likely to file a DIV. Such behavior follows naturally from their business model based on patent assertion.

Provisional applications do not crowd out other tools for delaying prosecution: they are systematically positively correlated with continuing application filing, especially for CONs. Possibly due to lower familiarity with subtle USPTO features, foreign entities – captured by the national stage entry of PCT applications or priority claims to foreign applications – are less likely to use continuing applications. Small entities display a lower probability of filing CONs or DIVs, but a higher one of filing CIPs, as would be the case if the knowledge their original applications disclose is more novel and triggers a string of subsequent improvements.

Table 2: Continuing applications and parent attributes

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(ind claims)	2.37***	0.95***	5.19***	2.42***	0.98***	5.30***	2.51***	0.98***	6.77***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)
Log(avg words in ind claims)	0.18***	0.15***	0.78***	0.05*	0.11***	0.76***	-0.72***	-0.00	0.67***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)
Small entity	-2.57***	2.74***	-1.74***	-1.33***	3.10***	-1.15***	-1.15***	3.19***	-1.31***
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.07)	(0.05)	(0.05)
IPAE	11.99***	3.53***	1.04**	12.42***	4.26***	1.35**	13.83***	3.39***	0.63
	(0.83)	(0.55)	(0.49)	(0.89)	(0.63)	(0.54)	(1.05)	(0.67)	(0.64)
Provisional	4.71***	0.70***	0.83***	4.01***	0.57***	0.58***	5.86***	1.11***	1.21***
	(0.05)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.07)	(0.05)	(0.06)
National stage entry	-0.84***	-1.77***	-1.25***	-2.60***	-2.40***	-2.49***	-1.48***	-1.69***	-1.53***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)
Foreign priority	-4.24***	-3.14***	-0.91***	-5.96***	-3.97***	-2.02***	-4.85***	-2.99***	-1.13***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
Log(1+DOCDB)				3.89***	1.18***	2.27***			
				(0.04)	(0.02)	(0.03)			
Log(1+papers)							2.03***	0.94***	0.99***
							(0.04)	(0.02)	(0.03)
Observations	3,024,498	3,024,498	3,024,498	2,458,508	2,458,508	2,458,508	1,965,524	1,965,524	1,965,524
R^2	0.05	0.04	0.08	0.06	0.04	0.08	0.08	0.05	0.11
Mean outcome	8.65	3.38	5.81	8.30	3.59	6.12	10.86	3.20	7.40

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on claims. Models 4-6 exclude applications filed after 2011. Models 7-9 exclude abandoned and pending applications. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Online Appendix Tables A6–A11 show results for similar models that use counts of child applications as outcomes, consider patents filed in the entire 1981-2018 period or only those filed prior to AIPA, exclude the number of independent claims from the regressions, and use the first or shortest claim's length as text-based scope measures.[23] These models confirm that continuing applications are used for more valuable technologies, when uncertainty and the benefits of keeping prosecution open are high, and by more sophisticated actors.

4.3 Office actions

Moving on to office actions and continuing applications, Table 3 displays the results of models based on Equation 3. Models 1, 3, and 5 omit two-way fixed effects, while models 2, 4, and 6 include them. The notice of allowance has a remarkably strong association with both CONs and DIVs: the probability of filing a CON increases by 613% and 620% relative to the sample mean following the first notice of allowance (models 1 and 2) and that of DIVs by 570% and 597% (models 5 and 6). Consistent with the notion that CIPs are relatively less reactive to parent patent grant, the notice of allowance is followed by an increase in the probability of filing a CIP of 81% and 100% (models 3 and 4).

Despite the common view that continuing applications are used to react to rejections in prosecution, our results paint a complex picture. The first final and non-final rejections are associated with higher probabilities of filing CONs in model 1, but the relationships become weaker or even negative when we add fixed effects in model 2. The opposite is true for CIPs, where model 4 with fixed effects suggests CIPs respond positively to first rejections, whereas model 3 implies small relationships of opposite sign. DIVs are negatively correlated with first rejections in model 5, but positively (negatively) related to the first final (non-final) rejection once model 6 adds fixed effects. Regardless of these relationships' sign, their magnitude is small both in absolute terms and relative to that found for the first notice of allowance. As expected, applicants have a stronger incentive to keep prosecution open by filing continuing

[23] The correlation between the two scope measures in the main analysis (number of independent claims and average length) is relatively low (correlation coefficient equal to -0.08). The measures of patent scope based on claim length are highly correlated, with correlation coefficients between 0.78 and 0.93.

Table 3: **Continuing applications and office actions: regressions**

Outcome	CON × 100		CIP × 100		DIV × 100	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)
Notice of allowance	4.01***	4.06***	0.25***	0.30***	2.11***	2.21***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Final rejection	0.49***	0.16***	0.02***	0.13***	-0.05***	0.07***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Non-final rejection	0.05***	-0.12***	-0.01***	0.05***	-0.15***	-0.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Restriction requirement	0.11***	0.00	0.09***	-0.00	2.26***	2.46***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Application FE		✓		✓		✓
Age by quarter FE		✓		✓		✓
Observations	59,702,420	59,627,046	59,702,420	59,627,046	59,702,420	59,627,046
R^2	0.03	0.11	0.00	0.13	0.03	0.10
Applications	4,675,687	4,600,313	4,675,687	4,600,313	4,675,687	4,600,313
Mean outcome	0.66	0.66	0.30	0.30	0.37	0.37

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample contains all the applications in our main analysis sample, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

applications after locking in a particular set of claims following the notice of allowance.

Table 3 also reports estimates for the association between the first restriction requirement and the likelihood of filing continuing applications. Models 1 and 3 suggest a positive relationship with CONs and CIPs, but the coefficients are close to and statistically indistinguishable from zero when models 2 and 4 add fixed effects. Unsurprisingly, DIVs increase dramatically, by 604% and 657% (models 5 and 6), after a restriction requirement.[24]

Next, we focus on the link between office actions and continuing application timing. We plot the β_τ's from four versions of Equation 4 in Figure 4, where Panels A, B and C analyze trends around the first notice of allowance and Panel D around the first restriction requirement. All panels show similar trends in the probability of filing continuing applications prior to a notice of allowance and the probability of filing a DIV before a restriction requirement

[24]Figure A2 analyzes these relationships by plotting the mean probability of filing continuing applications around the office actions retaining in the sample only applications receiving the relevant office action for each panel. The results suggest our findings in Table 3 are driven by an increase in continuing application filings for applications receiving the relevant office action, rather than by a decrease in child application filings for applications not receiving it.

for applications that receive the office action and those that do not.[25] We observe a large spike in the probability of filing a CON or DIV immediately after a notice of allowance; the probability of filing a CIP also increases after a notice of allowance, but is of much lower magnitude.[26] We interpret these findings as strong evidence that patent applicants use continuing applications (especially CONs and DIVs) to keep patent prosecution open after they receive a notice of allowance. The probability of DIV filing increases substantially after a restriction requirement, but more gradually: patentees can file DIVs as long as the parent application is pending, so there is no high time pressure and this gradual increase suggests many patent applicants prefer delaying the drafting of claims of DIVs.

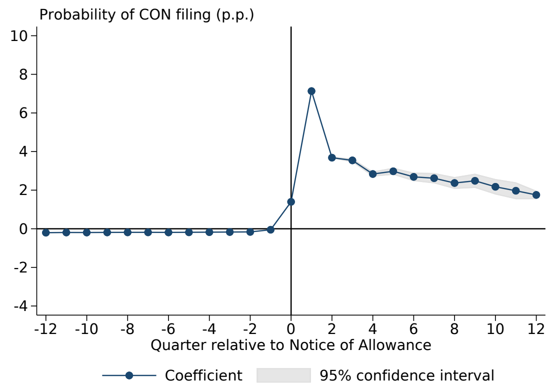
The Online Appendix reports the results of additional checks and analyses. As continuing applications are relatively rare outcomes, we estimate linear probability models of the filing of the first continuing application of each type where applications exit the estimation sample after the first CON, CIP, or DIV, so these regressions can be interpreted as discrete-time piecewise constant hazard models. The results in Table A12 match those in the main text. We also estimate models based on Equation 4 that include application effects λ_i and calendar-quarter-by-age effects δ_{at} and report the results in Figure A3. In these models, we omit the $\tau = -1$ dummy to avoid collinearity between the fixed effects and the X_{it}^{τ} indicators. The results again match those reported in Figure 4.

Our interpretation of results may be problematic if the observed association between the notice of allowance and child applications is driven by applications that reopen parent patent prosecution after the first such notice (instead of locking in advantages with the issuance of a first set of claims) and also spawn child applications. We use data on prosecution history until the end of our sample period to identify such applications, taking the occurrence of another notice of allowance, rejection, response to a rejection, request for continued examination, or

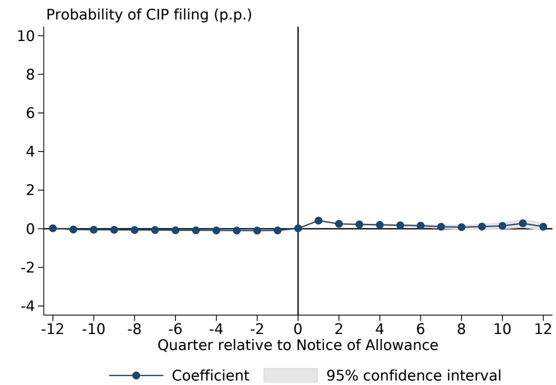
[25] F-tests reject the null hypothesis that pre-notice-of-allowance and pre-restriction-requirement dummies are jointly equal to zero in all specifications, but we think this is mostly due to our large sample size.

[26] Applicants can prolong an application's pendency after a notice of allowance by reopening prosecution, usually with a request for continued examination (RCE). Our sample includes 110,925 applications whose prosecution is reopened after the first notice of allowance by an RCE, so we have a large number of post-notice-of-allowance observations and can precisely estimate all lags of the notice of allowance indicator.

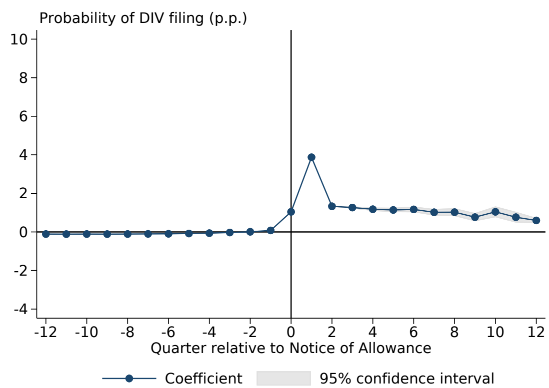
Figure 4: Office actions and continuing application timing



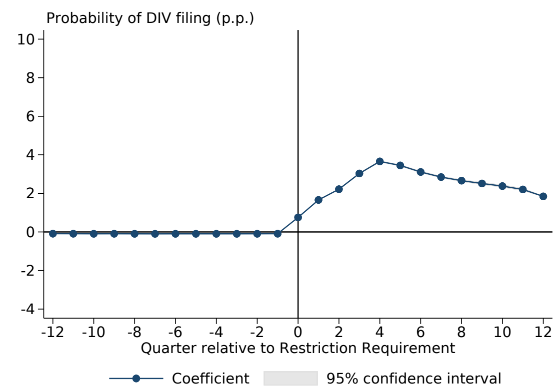
(A) Notice of Allowance and CONs



(B) Notice of Allowance and CIPs



(C) Notice of Allowance and DIVs



(D) Restriction Requirement and DIVs

Notes. Each panel plots the β_τ's (solid line) and 95% confidence intervals (shaded area) from OLS regressions based on Equation 4. Panels A, B, and C display trends around the first notice of allowance; Panel D displays trends around the first restriction requirement. The outcomes are indicators equal to one (multiplied by 100) if an application has at least one CON (Panel A), CIP (Panel B), or DIV (Panels C and D) in a quarter. The unit of observation is the application-calendar-quarter. The sample contains all the applications in our main analysis sample, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application.

appeal after the first notice of allowance as signs of prosecution reopening. These applications indeed have a higher mean number of continuing applications (0.24 CONs, 0.11 CIPs, and 0.12 DIVs) than the rest of the sample. However, applications that reopen prosecution after the first notice of allowance have roughly twice as many child applications both before (0.04 CONs, 0.07 CIPs, 0.02 DIVs) and after (0.2 CONs, 0.03 CIPs, 0.09 DIVs) the office action than applications that receive a notice of allowance, but do not reopen prosecution (0.01

CONs, 0.03 CIPs, 0.01 DIVs before, 0.1 CONs, 0.01 CIPs, 0.06 DIVs after). To the extent this represents a time-invariant higher propensity of applications reopening prosecution to generate child patents, our application fixed effects capture this difference in levels.

The remaining challenge is that applications reopening prosecution may have a disproportionately higher probability to generate child patents *after* the first notice of allowance even conditioning on application fixed effects, thus driving our core estimates. We provide additional evidence favoring our interpretation, highlighting that patentees allow the parent patent to issue soon after the first notice of allowance in the vast majority of cases and that reopening prosecution is a rare event. 95% of applications receiving a notice of allowance are granted before the end of our sample period; this percentage may even be slightly underestimated, as applications receiving a notice of allowance in the final quarters of our sample period may be granted immediately after. Indeed, using all the information on patent grants in PatEx after the end of our sample period, this percentage rises to 98%. Moreover, excluding all applications still pending at the end of our sample period so we can focus on those for which we observe the entire prosecution history, 96% of allowed applications receive only one notice of allowance. More importantly, only 117,644 applications (2.5%) reopen prosecution. This rare event and the rules governing the timing of patent issuance after the notice of allowance (Section 2.5) explain why 95% of applications receiving a notice of allowance remain in our estimation sample for at most two quarters following the first notice. Child patents filed long after the first notice of allowance are thus unlikely to drive our results.

As reopening prosecution after the first notice of allowance is rare, we confirm that its impact on our results is minimal in the Online Appendix. Table A13 reports the results of models similar to those in Table 3 addressing prosecution reopening. For simplicity, we exclude other office actions from the models; the first two columns show that this exclusion does not substantially affect the notice of allowance indicator coefficient. Focusing on short-run responses, we obtain similar results when we exclude from the sample the quarters after the second or first quarters following the first notice of allowance. In the final columns, we simply exclude applications whose prosecution is reopened after the first notice of allowance, with similar results. In Table A14, we exclude all applications still pending at the end of our sample period and assess how child applications respond to the *last* notice of allowance – the final chance to lock in gains with the parent patent issuance. In practice, the overwhelming majority of allowed applications receive only one notice of allowance, so the results remain unchanged. Tables A15 and A16 document similar estimated coefficients when we only study applications granted during our sample period. This allays concerns that our results could be driven by applications that are allowed, but whose applicant reopens prosecution and fails to eventually get a patent. Overall, these findings support our interpretation that patent applicants file continuing applications after they know a first patent will be issued.

We then test the robustness of our two-way fixed effects estimates of the link between the notice of allowance and continuing applications. The Online Appendix reports the results of several estimators designed to address potential biases in two-way fixed effects regressions with heterogeneous effects and staggered treatment. Reassuringly, the estimates in Table A18 and Figures A4–A6 are consistent with those in the main analysis.

We proceed by testing the idea that longer prosecution's higher gains should be manifest for science-based patents and IPAEs. Table 4, Panel A displays results for variations of Equation 3 including an indicator for patents building on science and its interaction with the notice of allowance; the remaining coefficient captures the interaction between notice of allowance and patents not building on science. For simplicity, we exclude dummies for other office actions from these models. The increase in CON and DIV filing following the notice of allowance is substantially higher for patents building on science than for others, consistent with applicants using such continuing applications to keep prosecution open for patents on technologies that require more time to resolve uncertainty around commercial applications. Science-based patents are on average more likely to generate a CIP, but they do not respond more strongly to a notice of allowance in filing a CIP (the coefficient is slightly lower than for other patents, but the difference is relatively small in economic terms).

Table 4: Heterogeneous effects of notice of the allowance

Outcome	CON × 100		CIP × 100		DIV × 100	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: patents building on science						
Science ×	5.62***	5.42***	0.26***	0.32***	3.22***	3.14***
Notice of allowance	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Other ×	3.68***	3.60***	0.30***	0.35***	1.91***	1.84***
Notice of allowance	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Science	0.11***		0.17***		0.04***	
	(0.00)		(0.00)		(0.00)	
Application FE		✓		✓		✓
Age by quarter FE		✓		✓		✓
Observations	39,011,113	38,984,997	39,011,113	38,984,997	39,011,113	38,984,997
R^2	0.03	0.12	0.00	0.13	0.02	0.10
Applications	3,106,488	3,080,385	3,106,488	3,080,385	3,106,488	3,080,385
Mean outcome	0.83	0.83	0.29	0.29	0.48	0.48
p-value, science vs. other	0.00	0.00	0.00	0.00	0.00	0.00
Panel B: IP-producing patent assertion entities						
IPAE ×	9.54***	9.64***	0.93***	0.81***	2.64***	2.55***
Notice of allowance	(0.35)	(0.36)	(0.19)	(0.16)	(0.20)	(0.21)
Other ×	4.14***	4.04***	0.25***	0.30***	2.23***	2.16***
Notice of allowance	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
IPAE	0.20***		0.44***		0.03	
	(0.03)		(0.06)		(0.02)	
Application FE		✓		✓		✓
Age by quarter FE		✓		✓		✓
Observations	59,702,420	59,627,046	59,702,420	59,627,046	59,702,420	59,627,046
R^2	0.03	0.11	0.00	0.13	0.01	0.09
Applications	4,675,687	4,600,313	4,675,687	4,600,313	4,675,687	4,600,313
Mean outcome	0.66	0.66	0.30	0.30	0.37	0.37
p-value, IPAE vs. other	0.00	0.00	0.00	0.00	0.05	0.06

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample contains all the applications in our main analysis sample, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. In Panel A, we retain only granted patents. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel B of Table 4 focuses on IPAE behavior. The rise in the probability of CON or CIP filing subsequent to a notice of allowance is twice as large for applications assigned to IPAEs relative to those assigned to other applicants, consistent with IPAEs' incentive to intensively exploit the delays in prosecution provided by continuations. The increase in the number of DIVs following the notice of allowance is only slightly higher for IPAEs. Overall, the evidence in Table 4 supports the use of continuing applications to prolong patent prosecution in more uncertain and strategic environments.

4.4 Scope narrowing

The evidence so far is consistent with applicants' use of continuations to craft claims on valuable inventions over time after locking in gains with an initial patent: parent abandonment has drastically decreased, continuations per original patent have increased, mainly respond to the original filing's notice of allowance, correlate with *ex ante* value markers and applicant identity, and have higher private value than original filings. Yet, less strategic explanations are available. During examination, applications usually go through several rounds of rejections and amendments narrowing their scope (Feng and Jaravel, 2020; Kuhn and Thompson, 2019; Marco et al., 2019), so a common belief is that applicants file continuing applications to wear down examiners when the original patent has narrowed significantly.

We test whether the likelihood of filing a continuing application increases following scope narrowing during examination in Table 5; since restriction requirements both narrow patents and generate divisionals, model 3 focuses on voluntary DIVs by excluding applications where this office action occurs. Contrary to what we would expect if the goal were to wear down examiners, reductions in the number of independent claims are associated to fewer CONs and CIPs, although these relationships are small in magnitude: a 1-standard deviation narrowing of independent claims (2.8 claims) is correlated with decreases in the likelihood of filing a CON or CIP of 0.27 and 0.12 percentage points, 2.7% and 3.4% from the mean, respectively. The evidence is consistent with wearing down examiners for voluntary DIVs: a 1-standard deviation narrowing of independent claims is associated with an increase in the chances of filing a voluntary DIV of 0.65 percentage points or 29% relative to the mean.

When we operationalize scope narrowing with the change in average independent claim length, we find positive relationships with CONs or CIPs, although again of limited practical significance: a 1-standard deviation reduction in average claim length implies a 0.21 and 0.1

Table 5: Continuing applications and parent scope narrowing

Outcome	CON × 100 (1)	CIP × 100 (2)	DIV × 100 (3)
Scope narrowing, independent claims	-0.27***	-0.12***	0.65***
	(0.03)	(0.03)	(0.07)
Scope narrowing, words per independent claim	0.21***	0.10***	-0.02
	(0.04)	(0.02)	(0.02)
Observations	1,477,798	1,477,798	1,172,516
R^2	0.08	0.06	0.06
Mean outcome	9.87	3.36	2.25

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims that are filed before 2012 and are eventually granted. The sample for column 3 excludes patents receiving a restriction requirement prior to the end of 2018. The scope narrowing measures are standardized. All models include as controls the attributes used in Table 2, as well as filing year and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

percentage point higher probability of filing a CON or CIP, or 2.1% and 3% relative to the mean, respectively. The coefficient is not statistically different from zero for DIVs.[27]

Online Appendix Table A19 reports robustness checks using alternative text-based scope narrowing measures.[28] The results are almost identical to our main ones, except for DIVs, which behave like other continuing applications when we measure narrowing based on the shortest claim. Overall, these estimates provide only limited evidence – in sign and magnitude – for the notion that applicants employ continuing applications to obtain broad patents or broad claims after the examination process narrowed the original application.

5 Discussion

Despite continuing applications' importance for patent prosecution strategies and frequent appearance in U.S. policy debates, only a handful of studies document their use. Their historical role in 'submarine patenting' has abated following the reforms introduced by TRIPS and AIPA, but the use of continuing applications subsided only temporarily in the late 1990s, rebounding strongly since in both number and share of total patents. We argue applicants

[27] The correlation between the two measures of scope narrowing is low (0.05). Results of specifications that separately include only one of the measures are almost identical to those in the main text.

[28] These measures are highly correlated, with correlation coefficients between 0.75 and 0.92.

have shifted attention towards keeping prosecution open after locking in gains with an initial patent, filing continuations to craft claims over time to increase the value of their patent portfolios and create barriers for competitors. Our empirical results support this interpretation, but several interesting observations also emerge.

5.1 Theoretical implications

Our findings add to a large literature on the strategic use of patents (Levin et al., 1987; Cohen et al., 2000; Hall and Ziedonis, 2001; Ziedonis, 2004), including continuations (Graham, 2004; Graham and Mowery, 2004; Hegde et al., 2009). These studies emphasize continuing applications' use to combine secrecy and delays prior to TRIPS and AIPA, build overlapping intellectual property rights for defensive purposes, and protect pioneering inventions. While Hegde et al. (2022) emphasize the private benefits of a quick patent prosecution, our analysis shows that continuing applications are often filed to *prolong* an application's prosecution after the first notice of allowance, with parent applications less likely to be abandoned. Continuing applications are generally not strongly correlated with changes in parent patent scope, but are filed for higher *ex ante* value technologies and their patents have higher private value on average. Our results indicate that applicants typically do not use continuing applications to obtain rejected or narrowed claims, but that delays in claim drafting can increase patent private value or, more generally, the value of patent portfolios after locking in initial gains. Selection likely plays a role, as our parent attributes analysis suggests, but child patents remain more valuable than their parents according to most value measures.

A burgeoning empirical literature on patent scope examines its determinants and relation to patents' economic value or examination process (Kuhn, 2016; Kuhn and Thompson, 2019; Marco et al., 2019). Our contribution here is to show that continuing applications represent an important instrument for applicants to change the scope of protection on an invention. Contrary to the idea that child applications are employed to react to claim narrowing during the original filing's prosecution, we find no clear relationship between patent scope changes during examination and the probability of filing continuing applications. There are, however, contrasting associations of the original application's scope based on number of claims or average claim length on the likelihood of filing a CON, CIP, or DIV: more work is required to study how the parent's scope at various stages of prosecution impacts continuing application use, estimate causal relationships, and examine the consequences of different strategies regarding scope over an invention's life-cycle.

Crafting claims over time is a valuable strategy, but it is difficult to precisely pin down whether its value comes from broadening scope or refining claims. This distinction is theoretically unclear. Claim refinement is often pursued with a view to broaden patent scope; for example, Meurer and Nard (2004, p. 1952) define refinement as 'the process of identifying and claiming the broadest patentable set of embodiments enabled by the disclosure in the patent specification'. Claim refinement, however, may also lead to narrow scope if applicants aim to tailor claims to a specific technological use (e.g. the applicant's or a competitor's product); such situations may allow patentees to extract substantial rents even from narrow claims. Yet, adding narrow claims with continuing applications may broaden an invention's scope of protection if those embodiments were not claimed in the original patent. Our data unfortunately do not allow us to disentangle the alternative sources of continuing application value: this analysis likely requires links between specific claims and products and measures of their fit unavailable in most areas, or an analysis of claim language that proposes new measures of patent family scope and claim refinement over time in very diverse technologies. This is a challenging, but interesting avenue for future work.

A particularly intriguing path forward is to understand precisely how continuing applications interact with the competition an applicant or invention faces, integrating important literature streams in innovation and strategy. Veihl (2022) take a first step in this direction, finding that continuations block competitors and increase concentration in their technological area. Another fruitful area concerns the link between child patents and milestones in technology development, with consequences for innovation and technology adoption. Righi and

Simcoe (2022) document that firms use continuations to obtain standard essential patents on ICT standards and that post-standard continuations are litigated at higher rates. Research could also examine child patents' strategic use in other settings and its consequences, carefully disentangling selection and treatment effects. Using the full population of post-AIPA patents, Righi (2022) shows that continuations lead to higher litigation rates exploiting the timing of continuation issuance and an instrumental variable design. Alternative outcomes, such as investments in startups and research-intensive organizations, technology licensing, and innovation offer exciting research opportunities.

Our study makes a novel contribution to understanding patent assertion entity behavior. Whereas previous work has studied the determinants of PAEs' patent acquisition, assertion strategies, and consequences (Cohen et al., 2019; Feng and Jaravel, 2020; Orsatti and Sterzi, 2019), we focus instead on the prosecution strategy of PAEs that produce their IP, such as pure upstream technology developers and companies purposely started by individual inventors. IPAEs not only file continuing applications at higher rates, but are also more responsive to notices of allowance, consistent with their strategic nature. We leave it for future work to probe these patenting strategies' implications for licensing and litigation, among others.

Finally, continuing applications are an important tool to delay claim drafting, but they are not the only one. Inventors can also exploit provisional and Patent Cooperation Treaty applications, extend the amount of time to respond to office actions with claim amendments, or file requests for continued examination and appeals. Moreover, similar forms of continuing applications and tools to delay claim drafting exist in other jurisdictions (Berger et al., 2012; Harhoff, 2016). How inventors use these tools, individually and/or jointly, and their collective effects on economic outcomes remain important questions.

5.2 Implications for patent data users

Our findings hold implications for researchers using patent data. Continuing applications protect the same invention, but issue as separate patents, which may lead to counting a given patented invention multiple times. Moreover, child applications' filing date is usually years after their parent's original filing date, so assigning patented inventions to time periods using patent filing date may lead to measurement error. We propose that researchers remedy these practical problems by counting just one invention per original patent and its CONs (and possibly CIPs, but not DIVs) and by using priority dates to assign inventions to time periods. We expand on these ideas in the Online Appendix and consider additional implications for research on knowledge spillovers, cumulative innovation, technology value, invention features such as originality or generality, R&D investments, and patent intensity.

5.3 Conclusion

TRIPS and AIPA curbed the most egregious uses of continuing applications in 'submarine patenting' and temporarily reduced their filing, but continuations have exhibited significant growth recently. We argue that a strategic use of continuing applications remains widespread, as applicants file continuations to keep prosecution open after locking in gains with an initial patent, with a view to broadening patent scope and creating barriers for competitors. Beyond a dramatic fall in parent abandonment and rise in continuations per original patent, we show that continuing applications have higher private value than original applications, are filed in more uncertain environments, for higher value technologies, by more strategic applicants, and respond strongly to the notice of allowance. Together, our evidence supports a current strategic use of continuing applications to craft claims over time.

References

Alcacer, J. and Gittelman, M. (2006). Patent citations as a measure of knowledge flows: The influence of examiner citations. *Review of Economics and Statistics*, 88(4):774–779.

Alcacer, J., Gittelman, M., and Sampat, B. (2009). Applicant and examiner citations in US patents: An overview and analysis. *Research Policy*, 38(2):415–427.

Allison, J. R. and Lemley, M. A. (2000). Who's patenting what? An empirical exploration of patent prosecution. *Vanderbilt Law Review*, 53(6):2099–2174.

Allison, J. R., Lemley, M. A., Moore, K. A., and Trunkey, R. D. (2004). Valuable patents. *Georgetown Law Journal*, 92(3):435–479.

Arora, A., Belenzon, S., and Sheer, L. (2017). Back to basics: Why do firms invest in research? NBER Working Paper 23187.

Baron, J. and Gupta, K. (2018). Unpacking 3GPP standards. *Journal of Economics & Management Strategy*, 27(3):433–461.

Baron, J. and Pohlmann, T. (2018). Mapping standards to patents using declarations of standard-essential patents. *Journal of Economics & Management Strategy*, 27(3):504–534.

Baron, J. and Spulber, D. (2018). Technology standards and standard setting organizations: Introduction to the Searle Center Database. *Journal of Economics & Management Strategy*, 27(3):462–503.

Baruffaldi, S. H. and Simeth, M. (2020). Patents and knowledge diffusion: The effect of early disclosure. *Research Policy*, 49(4):103927.

Bekkers, R., Catalini, C., Martinelli, A., Righi, C., and Simcoe, T. (2017). Disclosure rules and declared essential patents. NBER Working Paper 23627.

Belenzon, S. and Schankerman, M. (2013). Spreading the word: Geography, policy, and knowledge spillovers. *Review of Economics and Statistics*, 95(3):884–903.

Berger, F., Blind, K., and Thumm, N. (2012). Filing behaviour regarding essential patents in industry standards. *Research Policy*, 41(1):216–225.

Bessen, J. (2008). The value of US patents by owner and patent characteristics. *Research Policy*, 37(5):932–945.

Bikard, M. and Marx, M. (2019). Bridging academia and industry: How geographic hubs connect university science and corporate technology. *Working paper*.

Borusyak, K., Jaravel, X., and Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *Working Paper*.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230.

Carley, M., Hedge, D., and Marco, A. (2015). What is the probability of receiving a U.S. patent? *Yale Journal of Law & Technology*, 17(1):203–223.

Chiang, T.-J. (2010). Fixing patent boundaries. *Michigan Law Review*, 108(4):523–576.

Cockburn, I. M., Kortum, S., and Stern, S. (2002). Are all patent examiners equal? The impact of examiner characteristics. NBER Working Paper 8980.

Cohen, L., Gurun, U. G., and Kominers, S. D. (2019). Patent trolls: Evidence from targeted firms. *Management Science*, 65(12):5461–5486.

Cohen, W. M., Nelson, R. R., and Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not). NBER Working Paper 7552.

Correia, S. (2016). Linear models with high-dimensional fixed effects: An efficient and feasible estimator. *Working paper*.

Cotropia, C. A. and Quillen Jr, C. D. (2019). Continuing patent applications and performance of the US Patent and Trademark Office as of fiscal year 2018. *Working paper*.

de Chaisemartin, C. and D'Haultfœuille, X. (2020a). Difference-in-differences estimators of intertemporal treatment effects. *Working Paper*.

de Chaisemartin, C. and D'Haultfœuille, X. (2020b). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–2996.

deGrazia, C., Pairolero, N. A., and Teodorescu, M. (2021). Shorter patent pendency without sacrificing quality: The use of examiner's amendments at the USPTO. *Research Policy*, 50(10):104360.

Farre-Mensa, J., Hegde, D., and Ljungqvist, A. (2020). What is a patent worth? Evidence from the US patent "lottery". *Journal of Finance*, 75(2):639–682.

Feng, J. and Jaravel, X. (2020). Crafting intellectual property rights: Implications for patent assertion entities, litigation, and innovation. *American Economic Journal: Applied Economics*, 12(1):140–181.

Frakes, M. D. and Wasserman, M. F. (2015). Does the US Patent and Trademark Office grant too many bad patents: Evidence from a quasi-experiment. *Stanford Law Review*, 67(3):613–676.

FTC (2003). To promote innovation: A proper balance of competition and patent law and policy. Technical report, U.S. Federal Trade Commission.

FTC (2011). The evolving IP marketplace: Aligning patent notice and remedies with competition. Technical report, U.S. Federal Trade Commission.

Galasso, A. and Schankerman, M. (2015). Patents and cumulative innovation: Causal evidence from the courts. *Quarterly Journal of Economics*, 130(1):317–369.

Gambardella, A., Giuri, P., and Luzzi, A. (2007). The market for patents in Europe. *Research Policy*, 36(8):1163–1183.

Gambardella, A., Harhoff, D., and Verspagen, B. (2008). The value of European patents. *European Management Review*, 5(2):69–84.

Gans, J. S., Hsu, D. H., and Stern, S. (2008). The impact of uncertain intellectual property rights on the market for ideas: Evidence from patent grant delays. *Management Science*, 54(5):982–997.

Gaulé, P. (2018). Patents and the success of venture-capital backed startups: Using examiner assignment to estimate causal effects. *Journal of Industrial Economics*, 66(2):350–376.

Glazier, S. C. (2003). *Patent Strategies for Business*. LBI Law & Business Institute, Washington D.C.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2):254–277.

Graham, S. J. (2004). Behind the patent's veil: Innovators' uses of patent continuation practice, 1975-2002. *Working paper*.

Graham, S. J. and Hegde, D. (2015). Disclosing patents' secrets. *Science*, 347(6219):236–237.

Graham, S. J., Marco, A. C., and Miller, R. (2018a). The USPTO patent examination research dataset: A window on patent processing. *Journal of Economics & Management Strategy*, 27(3):554–578.

Graham, S. J., Marco, A. C., and Myers, A. F. (2018b). Patent transactions in the marketplace: Lessons from the USPTO patent assignment dataset. *Journal of Economics & Management Strategy*, 27(3):343–371.

Graham, S. J. and Mowery, D. C. (2004). Submarines in software? Continuations in US software patenting in the 1980s and 1990s. *Economics of Innovation and New Technology*, 13(5):443–456.

Hall, B. H., Jaffe, A. B., and Trajtenberg, M. (2001). The NBER patent citation data file: Lessons, insights and methodological tools. NBER Working Paper 8498.

Hall, B. H. and Ziedonis, R. H. (2001). The patent paradox revisited: An empirical study of patenting in the US semiconductor industry, 1979-1995. *RAND Journal of Economics*, 32(1):101–128.

Harhoff, D. (2016). Patent quality and examination in Europe. *American Economic Review: Papers & Proceedings*, 106(5):193–97.

Harhoff, D., Scherer, F. M., and Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. *Research Policy*, 32(8):1343–1363.

Hegde, D., Ljungqvist, A., and Raj, M. (2022). Quick or broad patents? Evidence from U.S. startups. *Review of Financial Studies*, 35(6):2705–2742.

Hegde, D. and Luo, H. (2018). Patent publication and the market for ideas. *Management Science*, 64(2):652–672.

Hegde, D., Mowery, D. C., and Graham, S. J. (2009). Pioneering inventors or thicket builders: Which US firms use continuations in patenting? *Management Science*, 55(7):1214–1226.

Hochberg, Y. V., Serrano, C. J., and Ziedonis, R. H. (2018). Patent collateral, investor commitment, and the market for venture lending. *Journal of Financial Economics*, 130(1):74–94.

Hussinger, K. and Schwiebacher, F. (2015). The market value of technology disclosures to standard setting organizations. *Industry and Innovation*, 22(4):321–344.

Katznelson, R. D. (2007). Patent continuations, product lifecycle contraction and the patent scope erosion – a new insight into patenting trends. In *Southern California Law Associations Intellectual Property Spring Seminar*.

Kuhn, J., Younge, K., and Marco, A. (2020). Patent citations reexamined. *RAND Journal of Economics*, 51(1):109–132.

Kuhn, J. M. (2016). Property rights and frictions in the sale of patents. *Working paper*.

Kuhn, J. M. and Thompson, N. C. (2019). How to measure and draw causal inferences with patent scope. *International Journal of the Economics of Business*, 26(1):5–38.

Lampe, R. (2012). Strategic citation. *Review of Economics and Statistics*, 94(1):320–333.

Lanjouw, J. O. (1998). Patent protection in the shadow of infringement: Simulation estimations of patent value. *Review of Economic Studies*, 65(4):671–710.

Lanjouw, J. O., Pakes, A., and Putnam, J. (1998). How to count patents and value intellectual property: The uses of patent renewal and application data. *Journal of Industrial Economics*, 46(4):405–432.

Lemley, M. A. and Moore, K. A. (2004). Ending abuse of patent continuations. *Boston University Law Review*, 84(1):63–123.

Lemley, M. A. and Sampat, B. (2012). Examiner characteristics and patent office outcomes. *Review of Economics and Statistics*, 94(3):817–827.

Lemley, M. A. and Shapiro, C. (2005). Probabilistic patents. *Journal of Economic Perspectives*, 19(2):75–98.

Lemley, M. A. and Shapiro, C. (2007). Patent holdup and royalty stacking. *Texas Law Review*, 85(7):1991–2050.

Levin, R. C., Klevorick, A. K., Nelson, R. R., Winter, S. G., and Gilbert, R. (1987). Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity*, 1987(3):783–831.

Marco, A. C. and Miller, R. (2019). Patent examination quality and litigation: Is there a link? *International Journal of the Economics of Business*, 26(1):65–91.

Marco, A. C., Sarnoff, J. D., and deGrazia, C. (2019). Patent claims and patent scope. *Research Policy*, 103790.

Martinez, C. (2010). Insight into different types of patent families. *Working paper.*

Marx, M. and Fuegi, A. (2020). Reliance on science: Worldwide front-page patent citations to scientific articles. *Strategic Management Journal*, 41(9):1572–1594.

Marx, M. and Fuegi, A. (2022). Reliance on science by inventors: Hybrid extraction of in-text patent-to-article citations. *Journal of Economics & Management Strategy*, 31(2):369–392.

Meurer, M. J. and Nard, C. A. (2004). Invention, refinement and patent claim scope: A new perspective on the doctrine of equivalents. *Georgetown Law Review*, 93:1947–2012.

Miller, R. (2020). Technical documentation for the 2019 patent examination research dataset (PatEx) release.

Miller, S. P. (2018). Who's suing us: Decoding patent plaintiffs since 2000 with the Stanford NPE Litigation Dataset. *Stanford Technology Law Review*, 21(2):235–275.

OECD (2009). *OECD Patent Statistics Manual.* OECD Publishing, Paris.

Orsatti, G. and Sterzi, V. (2019). NPEs, the market for patents and follow on innovation. Evidence from patent transfers at the USPTO. *Working paper.*

Pakes, A. (1986). Patents as options: Some estimates of the value of holding European patent stocks. *Econometrica*, 54(4):755–784.

Pohlmann, T., Neuhäusler, P., and Blind, K. (2016). Standard essential patents to boost financial returns. *R&D Management*, 46(S2):612–630.

Putnam, J. (1996). The value of international patent protection. *Unpublished Ph.D. Dissertation, Yale University.*

Quillen, C. D. J. and Webster, O. H. (2001). Continuing patent applications and performance of the US Patent and Trademark Office. *Federal Circuit Bar Journal*, 11(1):1–21.

Quillen, C. D. J., Webster, O. H., and Eichmann, R. (2002). Continuing patent applications and performance of the US Patent and Trademark Office-extended. *Federal Circuit Bar Journal*, 12(1):35–55.

Righi, C. (2022). Continuation patents and litigation. *Working paper*.

Righi, C. and Simcoe, T. (2019). Patent examiner specialization. *Research Policy*, 48(1):137–148.

Righi, C. and Simcoe, T. (2022). Patenting inventions or inventing patents? Continuation practice at the USPTO. NBER Working Paper 27686.

Rivette, K. G. and Kline, D. (2000). Discovering new value in intellectual property. *Harvard Business Review*, 78:54–66.

Roach, M. and Cohen, W. M. (2013). Lens or prism? Patent citations as a measure of knowledge flows from public research. *Management Science*, 59(2):504–525.

Roin, B. N. (2005). The disclosure function of the patent system (or lack thereof). *Harvard Law Review*, 118(6):2007–2028.

Rysman, M. and Simcoe, T. (2008). Patents and the performance of voluntary standard-setting organizations. *Management science*, 54(11):1920–1934.

Scherer, F. M. (1965). Firm size, market structure, opportunity, and the output of patented inventions. *American Economic Review*, 55(5):1097–1125.

Scherer, F. M. (1983). The propensity to patent. *International Journal of Industrial Organization*, 1(1):107–128.

Serrano, C. J. (2010). The dynamics of the transfer and renewal of patents. *RAND Journal of Economics*, 41(4):686–708.

Seymore, S. B. (2009). The teaching function of patents. *Notre Dame Law Review*, 85(2):621–669.

Shapiro, C. (2001). Navigating the patent thicket: Cross licenses, patent pools, and standard setting. In Jaffe, A. B., Lerner, J., and Stern, S., editors, *Innovation Policy and the Economy*, volume 1, pages 119–150. MIT press, Cambridge, MA.

Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199.

Veihl, M. (2022). The dark side of patents: Strategic patenting, product market entry and competitor innovation. *Working paper*.

Younge, K. A. and Kuhn, J. M. (2016). Patent-to-patent similarity: A vector space model. *Working paper*.

Ziedonis, R. H. (2004). Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. *Management Science*, 50(6):804–820.

Online Appendix

Alternative estimators for two-way fixed effects models

A burgeoning literature highlights a potential bias in two-way fixed effects regressions with heterogeneous effects and staggered treatment (Goodman-Bacon, 2021), so we examine the robustness of our results to using newly proposed estimators to address this concern. Since estimating these models is computationally demanding, we use a 0.5% random sample of the applications used in our main analysis and run simpler models that do not include other office actions and do not control for application age. Table A17 shows these simpler models estimated with OLS on the random sample produce coefficients of the notice of allowance that are similar to those of two-way fixed effects OLS regressions that include the other office actions and age-by-calendar-quarter effects, as well as those in Table 3.

Table A18 reports the results of models that use new estimators. de Chaisemartin and D'Haultfœuille (2020b) show that linear regressions with period and group fixed effects can produce biased estimates of treatment effects when the effect is not constant across groups or periods because of negative weights for some group-periods. The de Chaisemartin and D'Haultfœuille (2020b) estimator in columns 1, 4 and 7 provides an unbiased estimate of the instantaneous effect of the notice of allowance even if the effect is heterogeneous over time or applications: the estimates are similar to those in the period of the notice of allowance in Figures 4 and A3 (although they have larger standard errors because of the smaller sample size). This is not surprising, as only 31 of the 33,635 (0.001%) weights of each regression in columns 2, 4, and 6 of Table A17 are negative.

Callaway and Sant'Anna (2021) propose an unbiased estimator for group-time average treatment effects that can be used to construct more aggregated parameters. In columns 2, 5 and 8 we report the weighted average of all group-time average treatment effects (where weights are proportional to group size). The estimates are smaller in magnitude than those in Table 3, but still detect a large and statistically significant increase in CONs and DIVs after the notice of allowance, whereas we cannot reject that the increase in CIPs is statistically different from zero. Next, columns 3, 6 and 9 report the results obtained with the 'imputation estimator' proposed by Borusyak et al. (2021). Overall, these results closely match those in our main analysis.

Finally, we produce event-study graphs using the estimators proposed in de Chaisemartin and D'Haultfœuille (2020a), Callaway and Sant'Anna (2021), Sun and Abraham (2021), and Borusyak et al. (2021). We focus on a 17-quarter window (≈4 years) around the notice of allowance. For the de Chaisemartin and D'Haultfœuille (2020a), Callaway and Sant'Anna (2021), and Borusyak et al. (2021) estimators we plot all 'placebos' and 'dynamic effects' for periods -8 to +8, whereas for the Sun and Abraham (2021) estimator we use a specification that adds application and calendar-quarter effects to Equation 4; we use the pre-notice-of-allowance period as reference category by omitting the dummy for $\tau = -1$, as well as a single indicator if $\tau \leq -8$ and a single indicator if $\tau \geq 8$. Results, reported in Figures A4, A5 and A6 are similar to those in the main analysis.

Implications for patent data users

Continuing applications pose two related problems for studies using patent counts to measure inventive activities (Scherer, 1965). First, by protecting the same invention as the parent but issuing as separate patents, they may lead to counting a given patented invention multiple times. Researchers could address this by counting just one invention for each original patent and its CONs. CIPs protect the same invention as their parent, but also disclose new subject matter. As DIVs are largely filed when the original application discloses more than one invention, they may be treated as independent inventions; conversely, 'voluntary DIVs' provide the same legal benefits of CONs and, to the best of our knowledge, there is no active monitoring of proper application labeling. Researchers should use their judgment in considering CIPs and DIVs as additional patents on the same invention protected by an original patent or a new invention.

Second, patented inventions are commonly assigned to time periods using the patent filing date under the assumption that patent applications are filed shortly after invention. For child applications this date is usually years after their parent's original filing date – often just before parent patent issuance – so failing to correct for this may lead to measurement error in invention timing. We therefore propose using priority dates to assign inventions to time periods, again using researcher judgment regarding the timing of inventions protected by CIPs because they disclose new technical content.[29]

Double counting and invention timing mismeasurement are also problematic for the vast literature using patent citations to measure knowledge spillovers, cumulative innovation, technology value, and inventions features such as originality or generality (Hall et al., 2001). These studies usually assume the invention protected by the citing patent builds upon the invention protected by the cited patent. Continuations may lead to repeat counting of two inventions' relationship because later filings in a family usually cite the references in earlier

[29]Our suggestions are inspired by practices common among researchers using data from multiple patent offices, who often must take into account that an invention can be protected by patents in multiple countries and therefore face similar problems. See, for example, OECD (2009).

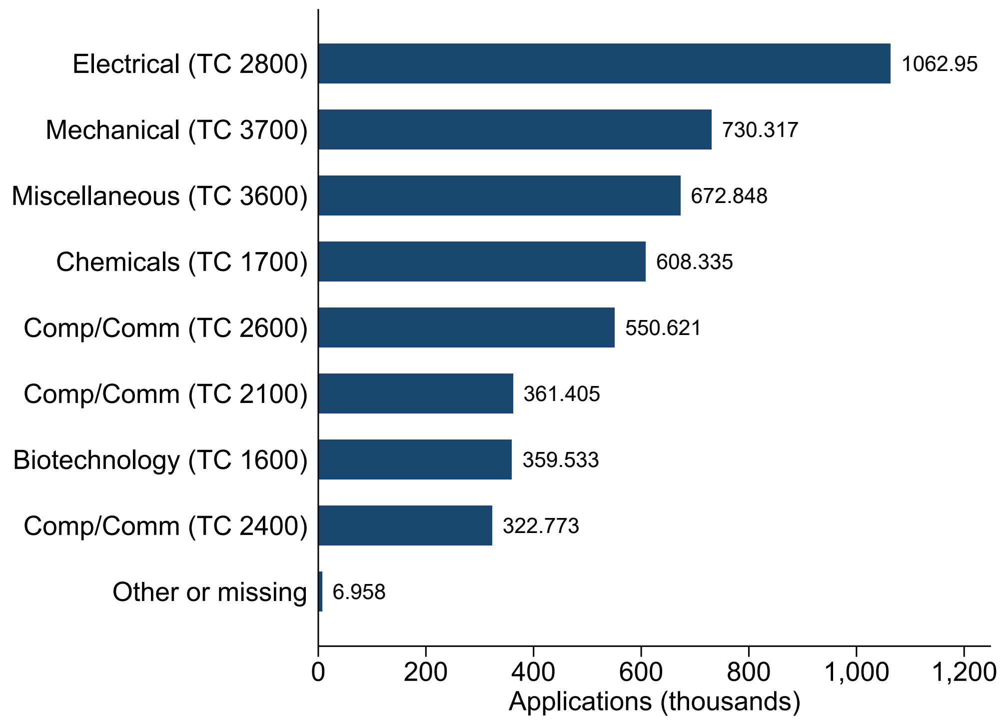
family members again (Kuhn et al., 2020; Lampe, 2012). Researchers may address this by collapsing citation data for an original application and its CONs to remove redundant citations, using their judgment on the nature of CIPs and DIVs as noted above.[30] Similarly, the invention timing considerations above are also relevant when researchers are interested in citation timing (e.g. counts of citations received by patents in a given time window), because it is common to assign citations to periods using the citing patent's application date. When the interest lies in patent private value, we also encourage researchers to rely on measures distinct from citations in light of our contrasting results with those in Hegde et al. (2009).

As patents from continuing applications are a substantial and growing share of the patents granted by the USPTO, the issues we highlight are more serious for studies using recent data. They are especially salient in technology areas where patentees have a higher propensity to employ continuing applications and for patents with characteristics correlated with their use. Moreover, accounting for child applications' different nature allows scholars to distinguish the extensive (whether an invention is patented) from the intensive (number of patents per patented invention) margins of patent propensity. Studies estimating the association between measures of R&D investments and patent intensity (Hall and Ziedonis, 2001; Scherer, 1983; Ziedonis, 2004) could also benefit from distinguishing between different patent types. Such analyses would improve our understanding of the propensity to patent the output of research activities, as well as child applications' use to build overlapping intellectual property rights around already-invented inventions – both relevant matters for patent policy.

[30] Kuhn et al. (2020) argue that cross-citing inside a patent family amplifies the citation of less relevant patents; however, they find that collapsing backward citations to the family level does not address the problem. Researcher discretion is advised when deciding to collapse the data to the family level.

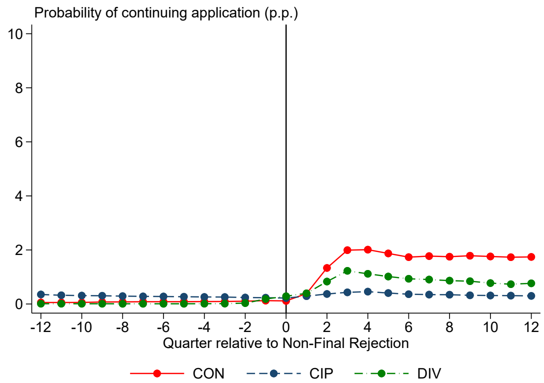
Additional figures and tables

Figure A1: Applications by Technology Center

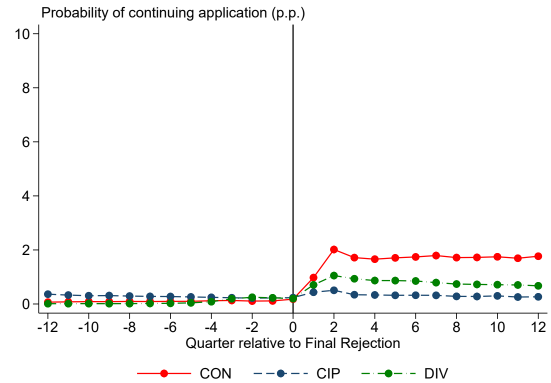


Notes. The sample is our main analysis sample.

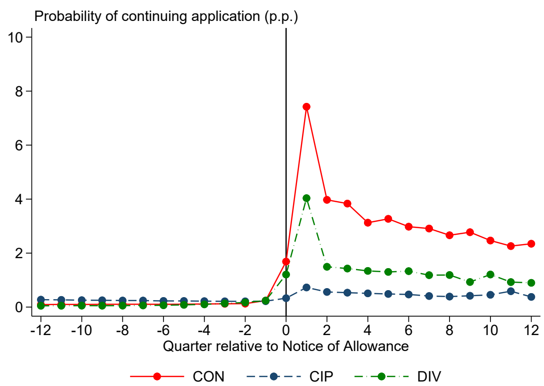
Figure A2: Continuing applications and office actions



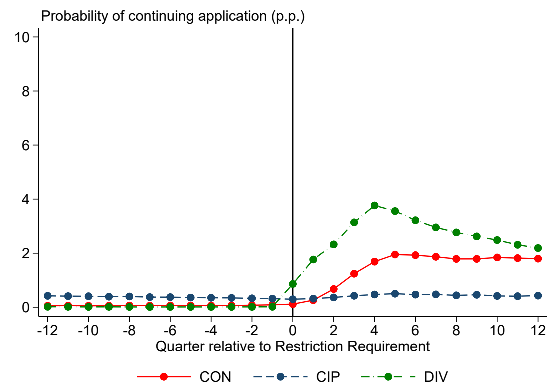
(A) Non-Final Rejection



(B) Final Rejection



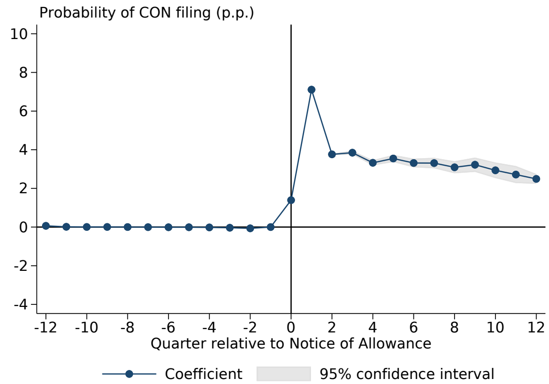
(C) Notice of Allowance



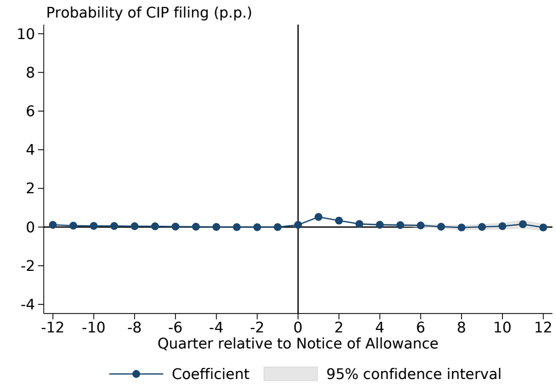
(D) Restriction Requirement

Notes. The panels plot the mean probability of child application filing for each type of child application around the first non-final rejection (Panel A), first final rejection (Panel B), first notice of allowance (Panel C), and first restriction requirement (Panel D). For each panel, the sample contains all the applications in our main analysis sample that receive the relevant office action at least once.

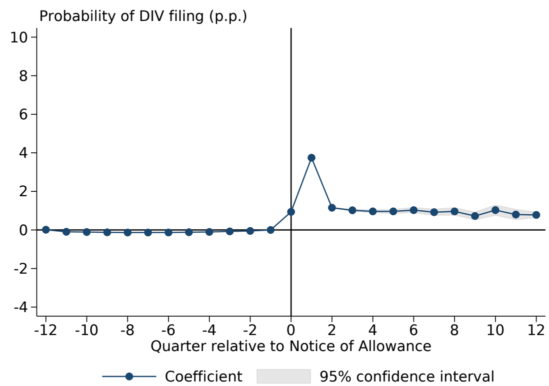
Figure A3: Office actions and continuing applications, two-way fixed effects



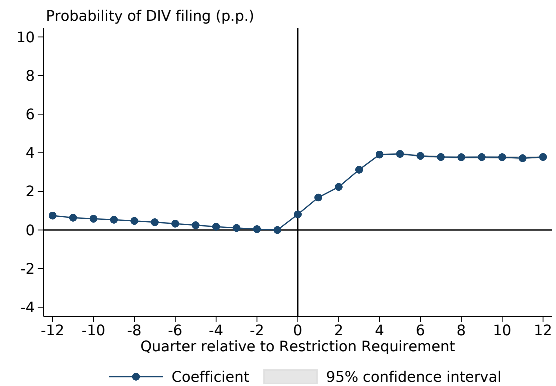
(A) Notice of Allowance and CONs



(B) Notice of Allowance and CIPs



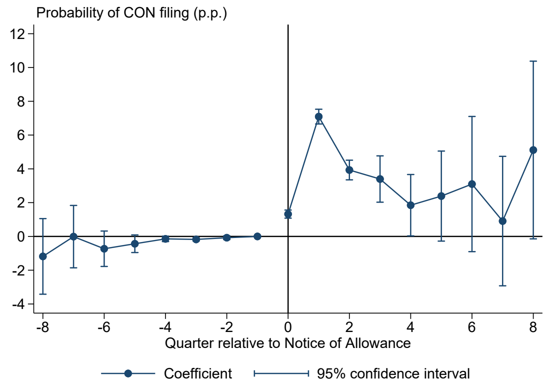
(C) Notice of Allowance and DIVs



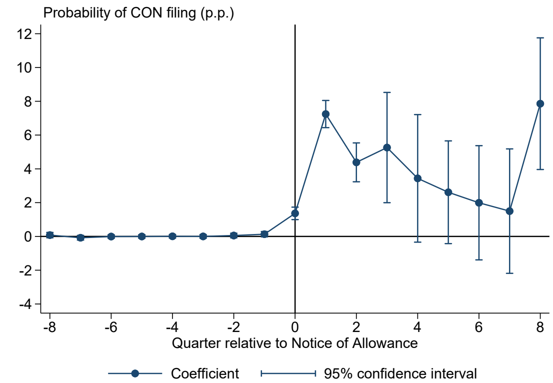
(D) Restriction Requirement and DIVs

Notes. Each panel plots the β_τ's (solid line) and their 95% confidence intervals (shaded area) from OLS regressions based on a modified version of Equation 4 that includes application and age-by-calendar-quarter effects. Panels A-C display trends around the first notice of allowance; Panel D displays trends around the first restriction requirement. The outcomes are indicators equal to one (multiplied by 100) if an application has at least one CON (Panel A), CIP (Panel B), or DIV (Panels C and D) in a quarter. The unit of observation is the application-calendar-quarter. The sample contains all the applications in our main analysis sample, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application.

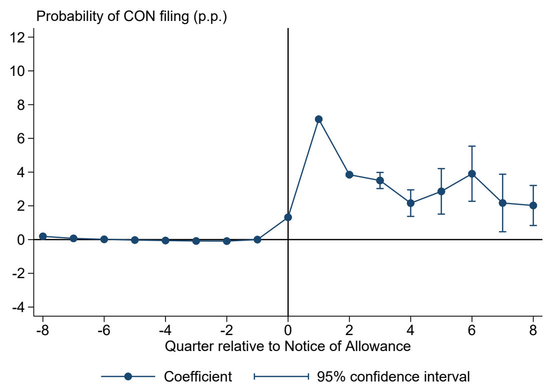
Figure A4: Event studies: notice of allowance and continuations



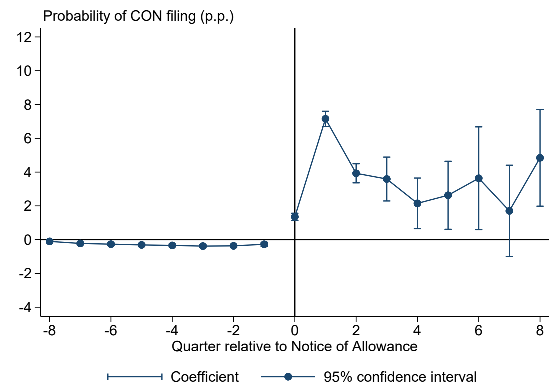
(A) DCDH



(B) CS



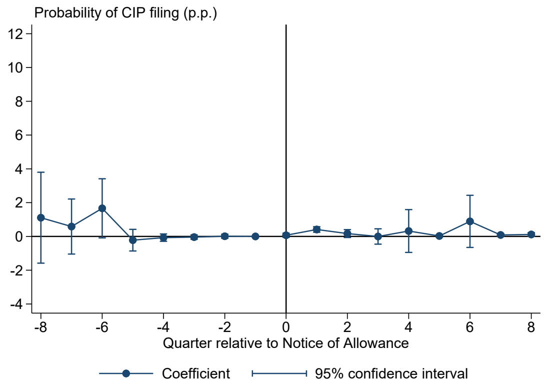
(C) SA



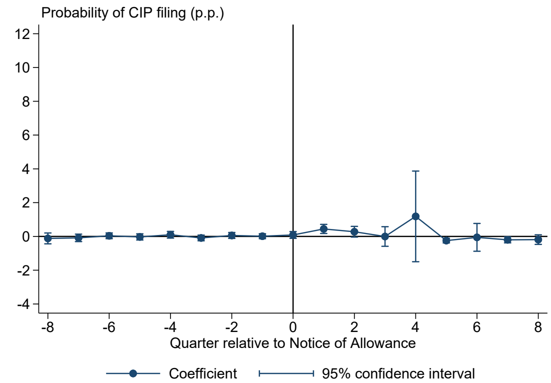
(D) BJS

Notes. The figure plots the coefficients and their 95% confidence intervals from event study specifications in a 17-quarter window around the first notice of allowance that include application and calendar-quarter effects. Each panel plots the estimates obtained with a different estimator: de Chaisemartin and D'Haultfœuille (2020a) in Panel A, Callaway and Sant'Anna (2021) in Panel B, Sun and Abraham (2021) in Panel C, and Borusyak et al. (2021) in Panel D. The outcome is an indicator equal to one if an application has at least one CON in a quarter (multiplied by 100). The unit of observation is the application-calendar-quarter. The sample contains a 0.5% random sample of the applications in the one in Table 3, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application (100 bootstrap repetitions for the de Chaisemartin and D'Haultfœuille (2020a) and Callaway and Sant'Anna (2021) estimators). We use the 'doubly robust' approach for the estimates in Panel B, and the applications that do not receive a notice of allowance as the control group for Panels B and C.

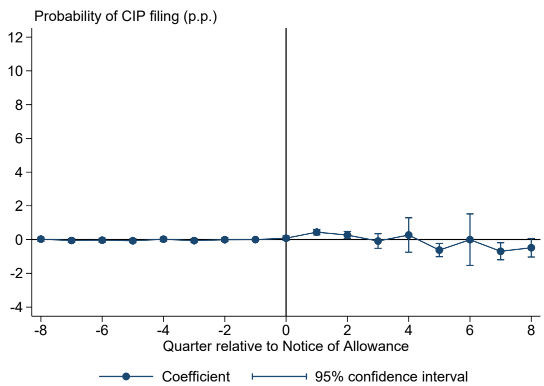
Figure A5: Event studies: notice of allowance and continuations-in-part



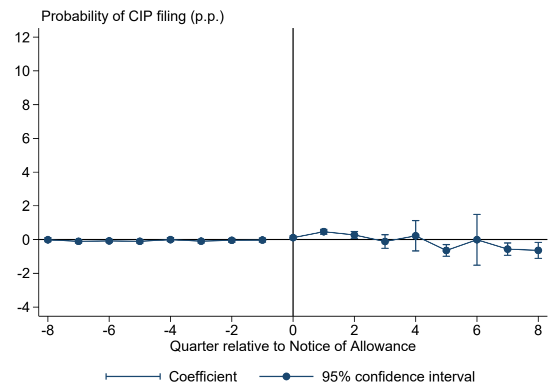
(A) DCDH



(B) CS



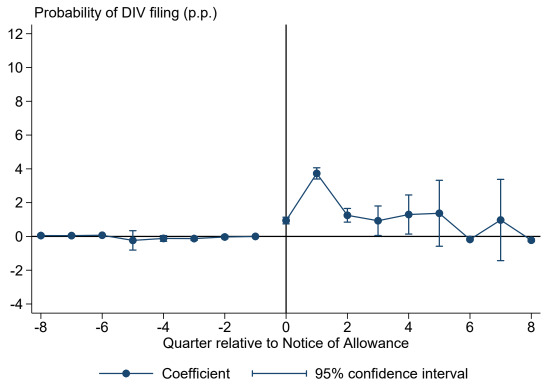
(C) SA



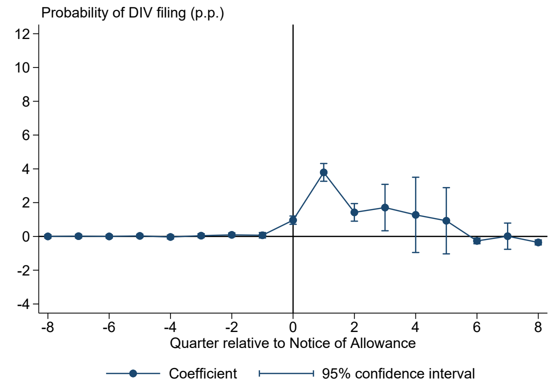
(D) BJS

Notes. The figure plots the coefficients and their 95% confidence intervals from event study specifications in a 17-quarter window around the first notice of allowance that include application and calendar-quarter effects. Each panel plots the estimates obtained with a different estimator: de Chaisemartin and D'Haultfœuille (2020a) in Panel A, Callaway and Sant'Anna (2021) in Panel B, Sun and Abraham (2021) in Panel C, and Borusyak et al. (2021) in Panel D. The outcome is an indicator equal to one if an application has at least one CIP in a quarter (multiplied by 100). The unit of observation is the application-calendar-quarter. The sample contains a 0.5% random sample of the applications in the one in Table 3, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application (100 bootstrap repetitions for the de Chaisemartin and D'Haultfœuille (2020a) and Callaway and Sant'Anna (2021) estimators). We use the 'doubly robust' approach for the estimates in Panel B, and the applications that do not receive a notice of allowance as the control group for Panels B and C.

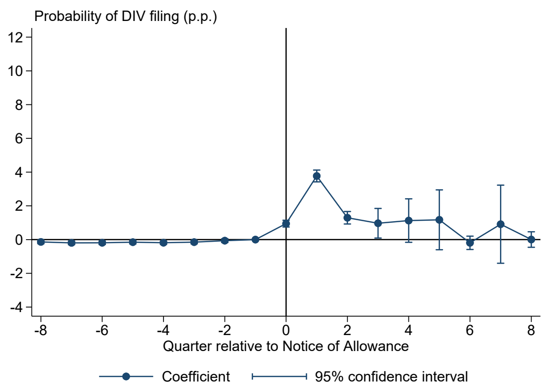
Figure A6: Event studies: notice of allowance and divisionals



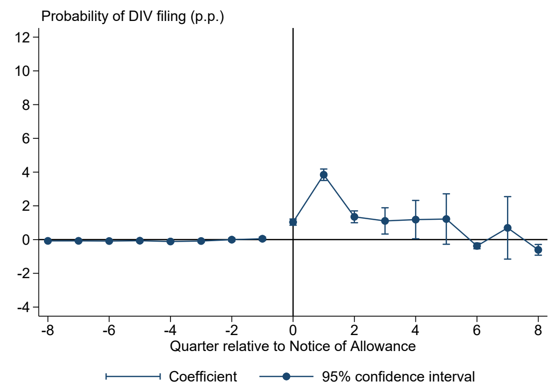
(A) DCDH



(B) CS



(C) SA



(D) BJS

Notes. The figure plots the coefficients and their 95% confidence intervals from event study specifications in a 17-quarter window around the first notice of allowance that include application and calendar-quarter effects. Each panel plots the estimates obtained with a different estimator: de Chaisemartin and D'Haultfœuille (2020a) in Panel A, Callaway and Sant'Anna (2021) in Panel B, Sun and Abraham (2021) in Panel C, and Borusyak et al. (2021) in Panel D. The outcome is an indicator equal to one if an application has at least one DIV in a quarter (multiplied by 100). The unit of observation is the application-calendar-quarter. The sample contains a 0.5% random sample of the applications in the one in Table 3, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application (100 bootstrap repetitions for the de Chaisemartin and D'Haultfœuille (2020a) and Callaway and Sant'Anna (2021) estimators). We use the 'doubly robust' approach for the estimates in Panel B, and the applications that do not receive a notice of allowance as the control group for Panels B and C.

Table A1: Summary statistics

Variables	(1) N	(2) Mean	(3) SD	(4) Min	(5) Median	(6) Max
CONs	4675738	0.12	0.75	0.00	0.00	572.00
CIPs	4675738	0.06	0.68	0.00	0.00	293.00
DIVs	4675738	0.07	0.39	0.00	0.00	92.00
CON	4675738	0.08	0.27	0.00	0.00	1.00
CIP	4675738	0.03	0.17	0.00	0.00	1.00
DIV	4675738	0.05	0.21	0.00	0.00	1.00
Published	4675738	0.93	0.26	0.00	1.00	1.00
Independent claims	3031071	2.95	2.65	0.00	3.00	620.00
Words per independent claim	3027600	126.79	108.45	0.00	107.00	18465.00
Words first independent claim	3022235	125.87	126.10	0.00	104.00	46194.00
Words shortest independent claim	3027600	104.59	102.24	0.00	85.00	18465.00
Provisional	4675738	0.24	0.43	0.00	0.00	1.00
National stage entry	4675738	0.23	0.42	0.00	0.00	1.00
Foreign priority	4675738	0.43	0.50	0.00	0.00	1.00
Small entity	4675725	0.25	0.43	0.00	0.00	1.00
DOCDB	2465908	2.04	2.50	0.00	1.00	51.00
References to science	3106492	3.74	19.53	0.00	0.00	3208.00
Issued	4675738	0.67	0.47	0.00	1.00	1.00
Abandoned	4675738	0.29	0.46	0.00	0.00	1.00
Change in independent claims	1566041	0.32	2.71	-83.00	0.00	619.00
Change in words per independent claim	1563902	45.90	97.19	-17860.00	30.00	9255.55
Change in words first independent claim	1563686	45.65	109.69	-33848.00	28.00	15654.00
Change in words shortest independent claim	1563902	48.16	98.89	-13183.00	30.00	9269.00
Notice of allowance	4675738	0.60	0.49	0.00	1.00	1.00
Final rejection	4675738	0.40	0.49	0.00	0.00	1.00
Non-final rejection	4675738	0.78	0.41	0.00	1.00	1.00
Restriction requirement	4675738	0.20	0.40	0.00	0.00	1.00
IPAE	4675738	0.00	0.03	0.00	0.00	1.00

Notes. The unit of observation is the application. The sample is our main analysis sample.

Table A2: Office actions and continuing applications

Type of child application	CON (1)	CIP (2)	DIV (3)
Non-final rejection			
Pr(non-final rejection): 78.49%			
Pr(Child after non-final rejection | non-final rejection)	0.73%	0.41%	0.74%
Pr(Child after non-final rejection | child)	7.07%	10.49%	12.42%
Final rejection			
Pr(final rejection): 39.69%			
Pr(Child after final rejection | final rejection)	1.72%	0.58%	1.19%
Pr(Child after final rejection | child)	8.42%	7.56%	10.11%
Notice of allowance			
Pr(notice of allowance): 59.52%			
Pr(Child after notice of allowance | notice of allowance)	9.27%	0.81%	5.12%
Pr(Child after notice of allowance | child)	68.20%	15.72%	65.35%
Restriction requirement			
Pr(restriction requirement): 20.06%			
Pr(Child after restriction requirement | restriction requirement)	0.52%	0.44%	3.54%
Pr(Child after restriction requirement | child)	1.30%	2.88%	15.21%

Notes. The unit of observation is the application. The sample is our main analysis sample. For each office action, the table reports the percentage of applications that receive the office action. For each office action and type of child application, the table reports: (i) the probability of filing the first child application within six months from the date of the first office action, conditional on receiving the office action; (ii) the probability that the first child application is filed within six months from the date of the first office action, conditional on generating a child application. We use a six-month window because applicants have six months to reply to a rejection (three plus an additional three if they pay a fee).

Table A3: Continuing applications and patent renewal fees after 8 and 12 years

Outcome	Renewed 8th year		Renewed 12th year	
Model	Baseline	Family effects	Baseline	Family effects
	(1)	(2)	(3)	(4)
Combination	1.14***	-14.00***	-5.32***	-12.89***
	(0.30)	(0.34)	(0.40)	(0.67)
CON	5.07***	-7.79***	2.84***	-8.14***
	(0.14)	(0.15)	(0.22)	(0.30)
CIP	4.62***	-5.85***	4.81***	-5.46***
	(0.20)	(0.22)	(0.30)	(0.35)
DIV	2.48***	-8.32***	0.35	-7.84***
	(0.16)	(0.15)	(0.24)	(0.25)
Observations	1,753,929	368,287	893,861	135,768
R^2	0.00	0.76	0.00	0.79
Mean outcome	66.69	74.05	45.08	52.82
Mean outcome, original	65.82	77.58	44.81	56.35

Notes. All models are estimated with OLS. All samples include granted patents from original and continuing applications filed between November 29, 2000 and the end of 2018. The sample for column 1 contains only patents issued before year 2013 that had to pay the eighth-year maintenance fee. The sample for column 3 contains only patents issued before year 2009 that had to pay the twelfth-year maintenance fee. The samples for columns 2 and 4 are the subsamples of patent families from the samples for columns 1 and 3 whose parent patent and at least one child patent are in the estimation sample. Robust standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Continuing applications and private value, patents filed in 1981-2018

Outcome	Renewed (4 years)	Litigated	Reassigned	Collateral	Licensed	Orange Book	SEP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: all patents							
Combination	4.32***	2.67***	10.45***	6.28***	1.77***	1.55***	1.76***
	(0.09)	(0.08)	(0.19)	(0.16)	(0.20)	(0.11)	(0.24)
CON	3.39***	1.11***	4.19***	2.44***	0.45***	1.74***	1.66***
	(0.05)	(0.03)	(0.07)	(0.05)	(0.08)	(0.10)	(0.08)
CIP	2.15***	1.38***	9.80***	5.39***	1.81***	0.68***	-0.07
	(0.08)	(0.04)	(0.12)	(0.10)	(0.14)	(0.07)	(0.05)
DIV	2.78***	0.14***	1.06***	2.11***	-0.09	0.04	1.91***
	(0.07)	(0.02)	(0.09)	(0.07)	(0.06)	(0.05)	(0.20)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Observations	5,118,119	4,821,288	6,412,408	6,412,408	246,872	418,310	1,523,334
R^2	0.00	0.01	0.02	0.01	0.01	0.01	0.01
Mean outcome	85.62	1.01	19.23	10.15	1.08	0.99	1.24
Mean outcome, original	84.87	0.74	18.09	9.42	0.61	0.58	0.91
Panel B: parent and child applications							
Combination	-8.88***	0.06	-2.19***	0.19*	0.72**	0.05	1.24***
	(0.11)	(0.10)	(0.16)	(0.11)	(0.36)	(0.17)	(0.19)
CON	-4.61***	0.65***	-1.26***	0.53***	0.66**	0.01	0.87***
	(0.06)	(0.05)	(0.09)	(0.07)	(0.28)	(0.11)	(0.11)
CIP	-3.87***	-0.04	0.07	0.64***	0.64***	-0.11	0.36***
	(0.09)	(0.06)	(0.11)	(0.07)	(0.23)	(0.11)	(0.06)
DIV	-5.23***	0.61***	-1.62***	0.87***	1.11***	0.07	1.11***
	(0.06)	(0.04)	(0.09)	(0.06)	(0.22)	(0.07)	(0.13)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Family effects	✓	✓	✓	✓	✓	✓	✓
Observations	1,225,602	1,126,561	1,661,277	1,661,277	64,685	132,251	372,320
R^2	0.67	0.62	0.83	0.90	0.71	0.72	0.79
Mean outcome	90.34	1.93	24.35	14.21	1.42	1.54	2.86
Mean outcome, original	92.55	1.92	25.49	14.69	1.69	1.44	2.83

Notes. All models are estimated with OLS. The unit of observation is the patent. All samples include granted patents from original and continuing applications filed between years 1981 and 2018 (inclusive). The sample for column 1 contains only patents issued before year 2017 that had to pay the fourth-year maintenance fee. The sample for column 2 contains only patents issued before year 2016. The sample for column 5 contains only patents in Biotechnology filed between years 1985 and 2004 (inclusive). The sample for column 6 contains only patents in Biotechnology issued between years 1985 and 2016 (inclusive). The sample for column 7 contains only patents in Computers and Communications filed before year 2016. The samples for Panel B are subsamples of patent families from the samples for Panel A whose parent patent and at least one child patent are in the estimation sample. Robust standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Continuing applications and private value, patents filed prior to AIPA

Outcome	Renewed (4 years)	Litigated	Reassigned	Collateral	Licensed	Orange Book	SEP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: all patents							
Combination	6.27***	2.84***	4.84***	3.11***	2.18***	1.13***	0.89***
	(0.13)	(0.11)	(0.26)	(0.21)	(0.25)	(0.12)	(0.23)
CON	4.20***	1.05***	-0.92***	0.11	0.55***	0.88***	0.25***
	(0.08)	(0.04)	(0.10)	(0.08)	(0.10)	(0.09)	(0.05)
CIP	2.08***	1.62***	8.56***	4.30***	2.24***	0.61***	0.25***
	(0.11)	(0.05)	(0.16)	(0.13)	(0.17)	(0.09)	(0.08)
DIV	3.55***	0.11***	-1.18***	0.85***	-0.17**	-0.03	0.90***
	(0.12)	(0.04)	(0.15)	(0.12)	(0.08)	(0.08)	(0.15)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Observations	2,182,076	2,186,396	2,186,461	2,186,461	182,481	194,356	506,379
R^2	0.00	0.00	0.01	0.01	0.01	0.00	0.01
Mean outcome	84.35	1.39	21.93	10.92	1.40	0.93	0.56
Mean outcome, original	83.47	1.09	21.41	10.50	0.80	0.65	0.48
Panel B: parent and child applications							
Combination	-6.70***	-0.50***	-3.24***	-0.72***	0.69	-0.29	0.34
	(0.20)	(0.18)	(0.34)	(0.23)	(0.50)	(0.24)	(0.26)
CON	-3.52***	0.09	-3.31***	-0.48***	0.72*	0.10	-0.23
	(0.15)	(0.13)	(0.23)	(0.16)	(0.41)	(0.18)	(0.19)
CIP	-4.12***	-0.46***	-0.18	-0.19	0.58*	-0.11	-0.11
	(0.14)	(0.10)	(0.19)	(0.12)	(0.32)	(0.14)	(0.11)
DIV	-4.54***	0.05	-2.92***	-0.17	1.19***	-0.19*	-0.10
	(0.11)	(0.07)	(0.17)	(0.11)	(0.30)	(0.11)	(0.17)
Grant year		✓				✓	
Filing year			✓	✓	✓		✓
Family effects	✓	✓	✓	✓	✓	✓	✓
Observations	347,315	348,173	348,196	348,196	41,909	44,629	50,996
R^2	0.71	0.68	0.85	0.91	0.75	0.69	0.87
Mean outcome	89.41	2.76	27.62	15.15	1.91	1.01	1.49
Mean outcome, original	91.28	2.77	29.17	14.94	2.12	1.12	1.26

Notes. All models are estimated with OLS. The unit of observation is the patent. All samples include granted patents from original and continuing applications filed after year 1980 and prior to November 29, 2000. The sample for column 1 contains only patents issued before year 2017 that had to pay the fourth-year maintenance fee. The sample for column 2 contains only patents issued before year 2016. The sample for column 5 contains only patents in Biotechnology filed after year 1984. The sample for column 6 contains only patents in Biotechnology issued between years 1985 and 2016 (inclusive). The sample for column 7 contains only patents in Computers and Communications. The samples for Panel B are subsamples of patent families from the samples for Panel A whose parent patent and at least one child patent are in the estimation sample. Robust standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Continuing applications and parent attributes, Poisson regressions

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CONs	CIPs	DIVs	CONs	CIPs	DIVs	CONs	CIPs	DIVs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(ind claims)	0.36***	0.38***	0.87***	0.36***	0.35***	0.85***	0.32***	0.33***	0.86***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Log(avg words in ind claims)	0.05***	0.03***	0.14***	0.03	0.00	0.13***	-0.05***	-0.02	0.09***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Small entity	-0.28***	0.42***	-0.36***	-0.15***	0.53***	-0.24***	-0.09***	0.46***	-0.21***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
IPAE	1.04***	0.93***	0.46***	1.17***	1.02***	0.52***	1.00***	0.88***	0.41***
	(0.06)	(0.11)	(0.13)	(0.07)	(0.11)	(0.14)	(0.06)	(0.12)	(0.14)
Provisional	0.55***	0.33***	0.22***	0.48***	0.25***	0.16***	0.51***	0.35***	0.22***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
National stage entry	-0.14***	-1.02***	-0.26***	-0.30***	-1.17***	-0.40***	-0.15***	-1.01***	-0.24***
	(0.01)	(0.03)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.04)	(0.01)
Foreign priority	-0.60***	-1.81***	-0.26***	-0.76***	-2.01***	-0.39***	-0.58***	-1.96***	-0.28***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)
Log(1+DOCDB)				0.41***	0.38***	0.35***			
				(0.01)	(0.01)	(0.01)			
Log(1+papers)							0.17***	0.33***	0.10***
							(0.00)	(0.01)	(0.00)
Observations	2,974,839	2,852,919	2,813,151	2,411,028	2,304,865	2,279,178	1,932,310	1,787,749	1,829,909
Mean outcome	0.14	0.08	0.09	0.14	0.08	0.10	0.18	0.08	0.12

Notes. All models are estimated with Poisson regressions. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims. Models 4-6 exclude applications filed after year 2011. Models 7-9 exclude abandoned and pending applications. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Continuing applications and parent attributes, patents filed 1981-2018

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Small entity	-1.18***	2.40***	-1.81***	-0.78***	2.60***	-1.71***	-1.24***	2.39***	-1.86***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
IPAE	8.62***	4.73***	2.05***	8.08***	5.48***	2.16***	8.57***	4.71***	2.01***
	(0.57)	(0.42)	(0.39)	(0.61)	(0.49)	(0.44)	(0.56)	(0.42)	(0.39)
Provisional	5.86***	1.11***	1.72***	6.38***	1.39***	2.18***	5.52***	0.90***	1.44***
	(0.05)	(0.03)	(0.04)	(0.07)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)
National stage entry	-1.50***	-1.46***	-1.67***	-1.84***	-2.11***	-2.72***	-1.65***	-1.54***	-1.77***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.05)	(0.04)	(0.02)	(0.03)
Foreign priority	-4.26***	-3.22***	-2.23***	-5.03***	-4.39***	-3.26***	-3.93***	-3.04***	-1.99***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
Log(1+DOCDB)				2.01***	1.05***	1.66***			
				(0.02)	(0.02)	(0.03)			
Log(1+papers)							1.92***	1.02***	1.33***
							(0.02)	(0.02)	(0.02)
Observations	4,676,275	4,676,275	4,676,275	3,316,134	3,316,134	3,316,134	4,640,386	4,640,386	4,640,386
R^2	0.08	0.04	0.08	0.09	0.04	0.08	0.08	0.04	0.08
Mean outcome	7.94	3.09	6.02	7.27	3.58	7.06	7.99	3.11	6.07

Notes. All models are estimated with OLS. The unit of observation is the patent. The samples include all the granted original patent applications filed between years 1981 and 2018 (inclusive). Models 4-6 exclude patents filed after year 2011. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A8: Continuing applications and parent attributes, patents filed prior to AIPA

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Small entity	-0.79***	1.61***	-2.19***	-0.34***	1.96***	-1.67***	-0.79***	1.60***	-2.20***
	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)
IPAE	5.43***	6.88***	2.15***	5.39***	6.84***	2.10***	5.47***	6.92***	2.19***
	(0.72)	(0.72)	(0.61)	(0.72)	(0.72)	(0.60)	(0.72)	(0.71)	(0.61)
Provisional	3.80***	1.07***	2.09***	3.74***	1.02***	2.01***	3.37***	0.61***	1.52***
	(0.13)	(0.12)	(0.13)	(0.13)	(0.12)	(0.13)	(0.13)	(0.12)	(0.13)
National stage entry	-0.09	-1.73***	-2.56***	-0.79***	-2.30***	-3.38***	-0.15**	-1.80***	-2.65***
	(0.08)	(0.05)	(0.09)	(0.08)	(0.05)	(0.09)	(0.08)	(0.05)	(0.09)
Foreign priority	-2.22***	-4.05***	-2.01***	-3.14***	-4.79***	-3.07***	-1.96***	-3.77***	-1.67***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)	(0.04)
Log(1+DOCDB)				1.42***	1.14***	1.65***			
				(0.03)	(0.03)	(0.03)			
Log(1+papers)							1.74***	1.85***	2.25***
							(0.04)	(0.04)	(0.04)
Observations	1,534,424	1,534,424	1,534,424	1,534,424	1,534,424	1,534,424	1,534,424	1,534,424	1,534,424
R^2	0.06	0.04	0.08	0.06	0.04	0.08	0.06	0.04	0.08
Mean outcome	3.66	3.70	6.44	3.66	3.70	6.44	3.66	3.70	6.44

Notes. All models are estimated with OLS. The unit of observation is the patent. The samples include all the granted original patent applications filed after year 1980 and prior to November 29, 2000. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A9: Continuing applications and parent attributes, no independent claims count

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(avg words in ind claims)	-0.04	0.06***	0.30***	-0.17***	0.02	0.26***	-0.97***	-0.10***	-0.01
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)
Small entity	-2.84***	2.63***	-2.32***	-1.60***	2.99***	-1.75***	-1.36***	3.11***	-1.87***
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.07)	(0.05)	(0.05)
IPAE	12.27***	3.65***	1.66***	12.75***	4.40***	2.07***	14.10***	3.49***	1.34**
	(0.83)	(0.55)	(0.50)	(0.89)	(0.63)	(0.55)	(1.05)	(0.67)	(0.65)
Provisional	4.92***	0.79***	1.29***	4.23***	0.66***	1.06***	6.03***	1.17***	1.66***
	(0.05)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.07)	(0.05)	(0.06)
National stage entry	-0.87***	-1.78***	-1.33***	-2.63***	-2.41***	-2.55***	-1.56***	-1.72***	-1.75***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)
Foreign priority	-4.79***	-3.35***	-2.11***	-6.55***	-4.21***	-3.32***	-5.46***	-3.22***	-2.77***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
Log(1+DOCDB)				3.94***	1.20***	2.38***			
				(0.04)	(0.02)	(0.03)			
Log(1+papers)							2.15***	0.98***	1.30***
							(0.04)	(0.02)	(0.03)
Observations	3,024,498	3,024,498	3,024,498	2,458,508	2,458,508	2,458,508	1,965,524	1,965,524	1,965,524
R^2	0.05	0.04	0.06	0.06	0.04	0.07	0.08	0.05	0.09
Mean outcome	8.65	3.38	5.81	8.30	3.59	6.12	10.86	3.20	7.40

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims. Models 4-6 exclude applications filed after year 2011. Models 7-9 exclude abandoned and pending applications. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A10: Continuing applications and parent attributes, words in first independent claim

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(ind claims)	2.39***	0.95***	5.18***	2.42***	0.99***	5.28***	2.53***	0.98***	6.75***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)
Log(words in first ind claim)	0.21***	0.13***	0.48***	0.05	0.10***	0.40***	-0.57***	-0.01	0.40***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.03)
Small entity	-2.57***	2.74***	-1.74***	-1.33***	3.10***	-1.16***	-1.15***	3.19***	-1.29***
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.07)	(0.05)	(0.05)
IPAE	11.97***	3.54***	1.06**	12.42***	4.26***	1.36**	13.79***	3.40***	0.65
	(0.83)	(0.55)	(0.49)	(0.89)	(0.63)	(0.54)	(1.05)	(0.67)	(0.64)
Provisional	4.70***	0.71***	0.82***	4.01***	0.57***	0.57***	5.86***	1.11***	1.19***
	(0.05)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.07)	(0.05)	(0.06)
National stage entry	-0.83***	-1.77***	-1.27***	-2.60***	-2.41***	-2.53***	-1.43***	-1.69***	-1.55***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)
Foreign priority	-4.25***	-3.14***	-0.91***	-5.96***	-3.98***	-2.01***	-4.84***	-2.99***	-1.13***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
Log(1+DOCDB)				3.89***	1.17***	2.27***			
				(0.04)	(0.02)	(0.03)			
Log(1+papers)							2.03***	0.94***	0.98***
							(0.04)	(0.02)	(0.03)
Observations	3,019,139	3,019,139	3,019,139	2,458,159	2,458,159	2,458,159	1,962,504	1,962,504	1,962,504
R^2	0.05	0.04	0.08	0.06	0.04	0.08	0.08	0.05	0.11
Mean outcome	8.64	3.38	5.80	8.30	3.59	6.12	10.85	3.20	7.38

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims. Models 4-6 exclude applications filed after year 2011. Models 7-9 exclude abandoned and pending applications. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A11: Continuing applications and parent attributes, words in shortest independent claim

Model	Application			Value			Science		
Sample	Published applications			Filed before 2012			Issued patents		
Outcome	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100	CON × 100	CIP × 100	DIV × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(ind claims)	2.43***	0.97***	5.29***	2.45***	1.00***	5.40***	2.37***	0.96***	6.80***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)
Log(words in shortest ind claim)	0.16***	0.08***	0.39***	0.09***	0.06***	0.39***	-0.51***	-0.04**	0.21***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.03)
Small entity	-2.57***	2.74***	-1.73***	-1.33***	3.10***	-1.14***	-1.17***	3.19***	-1.29***
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.07)	(0.05)	(0.05)
IPAE	11.98***	3.53***	1.04**	12.41***	4.27***	1.35**	13.84***	3.39***	0.64
	(0.83)	(0.55)	(0.49)	(0.89)	(0.63)	(0.54)	(1.05)	(0.67)	(0.64)
Provisional	4.71***	0.70***	0.83***	4.01***	0.57***	0.58***	5.86***	1.11***	1.20***
	(0.05)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.07)	(0.05)	(0.06)
National stage entry	-0.83***	-1.76***	-1.24***	-2.59***	-2.40***	-2.50***	-1.49***	-1.70***	-1.54***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)
Foreign priority	-4.24***	-3.13***	-0.88***	-5.96***	-3.97***	-1.99***	-4.87***	-2.98***	-1.09***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
Log(1+DOCDB)				3.89***	1.18***	2.28***			
				(0.04)	(0.02)	(0.03)			
Log(1+papers)							2.02***	0.94***	0.99***
							(0.04)	(0.02)	(0.03)
Observations	3,024,459	3,024,459	3,024,459	2,458,469	2,458,469	2,458,469	1,965,504	1,965,504	1,965,504
R^2	0.05	0.04	0.08	0.06	0.04	0.08	0.08	0.05	0.11
Mean outcome	8.65	3.38	5.81	8.30	3.59	6.12	10.86	3.20	7.40

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims. Models 4-6 exclude applications filed after year 2011. Models 7-9 exclude abandoned and pending applications. All models include filing-year effects and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A12: Continuing applications and office actions, hazard models

Outcome	First CON × 100		First CIP × 100		First DIV × 100	
Model	Baseline	Age by quarter	Baseline	Age by quarter	Baseline	Age by quarter
	(1)	(2)	(3)	(4)	(5)	(6)
Notice of allowance	4.03***	4.01***	0.19***	0.21***	2.15***	2.17***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Final rejection	0.48***	0.23***	-0.02***	0.11***	-0.05***	0.06***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Non-final rejection	0.04***	0.01***	-0.03***	0.08***	-0.16***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Restriction requirement	0.10***	0.06***	0.02***	0.07***	2.32***	2.36***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Age by quarter FE		✓		✓		✓
Observations	59,120,297	59,120,297	58,663,830	58,663,830	59,291,435	59,291,435
R^2	0.03	0.03	0.00	0.00	0.03	0.03
Applications	4,675,687	4,675,687	4,675,687	4,675,687	4,675,687	4,675,687
Mean outcome	0.63	0.63	0.24	0.24	0.37	0.37

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample contains all the applications in our main analysis sample, with applications retained in the sample from their filing quarter to the earliest of the quarter of the realization of the outcome, disposal quarter, or the end of 2018. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A13: Continuing applications and notice of allowance, robustness to reopening prosecution

Applications	All						Excluded if prosecution reopened					
Time periods	All		Up to NOA + 2		Up to NOA + 1		All		Up to NOA + 2		Up to NOA + 1	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: CONs												
NOA	4.14***	4.05***	4.19***	4.07***	4.27***	4.12***	4.16***	4.07***	4.22***	4.10***	4.34***	4.20***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	59,702,420	59,627,046	59,374,442	59,299,068	58,414,827	58,339,453	57,779,214	57,703,842	57,663,258	57,587,886	56,812,343	56,736,971
R^2	0.03	0.11	0.03	0.11	0.03	0.12	0.03	0.11	0.03	0.11	0.03	0.12
Applications	4,675,687	4,600,313	4,675,687	4,600,313	4,675,687	4,600,313	4,558,043	4,482,671	4,558,043	4,482,671	4,558,043	4,482,671
Mean outcome	0.66	0.66	0.64	0.64	0.59	0.59	0.63	0.63	0.63	0.63	0.58	0.59
Panel B: CIPs												
NOA	0.25***	0.30***	0.25***	0.30***	0.25***	0.30***	0.26***	0.31***	0.26***	0.31***	0.25***	0.31***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	59,702,420	59,627,046	59,374,442	59,299,068	58,414,827	58,339,453	57,779,214	57,703,842	57,663,258	57,587,886	56,812,343	56,736,971
R^2	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13
Applications	4,675,687	4,600,313	4,675,687	4,600,313	4,675,687	4,600,313	4,558,043	4,482,671	4,558,043	4,482,671	4,558,043	4,482,671
Mean outcome	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.29	0.29
Panel C: DIVs												
NOA	2.23***	2.16***	2.29***	2.19***	2.45***	2.34***	2.28***	2.20***	2.32***	2.22***	2.49***	2.39***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	59,702,420	59,627,046	59,374,442	59,299,068	58,414,827	58,339,453	57,779,214	57,703,842	57,663,258	57,587,886	56,812,343	56,736,971
R^2	0.01	0.09	0.01	0.09	0.01	0.10	0.01	0.09	0.01	0.09	0.01	0.10
Applications	4,675,687	4,600,313	4,675,687	4,600,313	4,675,687	4,600,313	4,558,043	4,482,671	4,558,043	4,482,671	4,558,043	4,482,671
Mean outcome	0.37	0.37	0.37	0.37	0.35	0.35	0.37	0.37	0.37	0.37	0.35	0.35

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample is the same as in Table 3. We exclude applications whose prosecution is reopened from the sample for columns 7-12. In columns 1-2 and 7-8, applications are retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. In columns 3-4 and 9-10, applications are retained in the sample from their filing quarter to the earliest of their disposal quarter, the second quarter after the first notice of allowance, or the end of 2018. In columns 5-6 and 11-12, applications are retained in the sample from their filing quarter to the earliest of their disposal quarter, the first quarter after the first notice of allowance, or the end of 2018. The outcome is constructed using CONs in Panel A, CIPs in Panel B, and DIVs in Panel C. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A14: Continuing applications and last notice of allowance

Applications	All						Excluded if prosecution reopened					
Time periods	All		Up to NOA + 2		Up to NOA + 1		All		Up to NOA + 2		Up to NOA + 1	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: CONs												
NOA	4.25***	4.00***	4.32***	4.05***	4.45***	4.15***	4.27***	4.01***	4.33***	4.05***	4.45***	4.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	53,643,318	53,643,141	53,501,939	53,501,760	52,609,538	52,609,349	53,565,061	53,564,885	53,443,911	53,443,732	52,555,107	52,554,918
R^2	0.03	0.11	0.03	0.11	0.03	0.12	0.03	0.11	0.03	0.11	0.03	0.12
Applications	3,876,936	3,876,764	3,876,929	3,876,754	3,876,923	3,876,738	3,873,310	3,873,138	3,873,303	3,873,128	3,873,297	3,873,112
Mean outcome	0.71	0.71	0.70	0.70	0.65	0.65	0.71	0.71	0.70	0.70	0.65	0.65
Panel B: CIPs												
NOA	0.25***	0.30***	0.25***	0.30***	0.24***	0.30***	0.25***	0.30***	0.25***	0.30***	0.24***	0.30***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	53,643,318	53,643,141	53,501,939	53,501,760	52,609,538	52,609,349	53,565,061	53,564,885	53,443,911	53,443,732	52,555,107	52,554,918
R^2	0.00	0.12	0.00	0.12	0.00	0.13	0.00	0.12	0.00	0.12	0.00	0.13
Applications	3,876,936	3,876,764	3,876,929	3,876,754	3,876,923	3,876,738	3,873,310	3,873,138	3,873,303	3,873,128	3,873,297	3,873,112
Mean outcome	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Panel C: DIVs												
NOA	2.29***	2.19***	2.33***	2.23***	2.51***	2.40***	2.30***	2.20***	2.33***	2.23***	2.51***	2.40***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	53,643,318	53,643,141	53,501,939	53,501,760	52,609,538	52,609,349	53,565,061	53,564,885	53,443,911	53,443,732	52,555,107	52,554,918
R^2	0.01	0.09	0.01	0.09	0.01	0.10	0.01	0.09	0.01	0.09	0.01	0.10
Applications	3,876,936	3,876,764	3,876,929	3,876,754	3,876,923	3,876,738	3,873,310	3,873,138	3,873,303	3,873,128	3,873,297	3,873,112
Mean outcome	0.41	0.41	0.41	0.41	0.39	0.39	0.41	0.41	0.41	0.41	0.39	0.39

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample is a subsample of the one in Table 3 that excludes applications pending as of the end of year 2018. We exclude applications whose prosecution is reopened from the sample for columns 7-12. In columns 1-2 and 7-8, applications are retained in the sample from their filing quarter to their disposal quarter. In columns 3-4 and 9-10, applications are retained in the sample from their filing quarter to the earliest of the second quarter after the last notice of allowance or their disposal quarter. In columns 5-6 and 11-12, applications are retained in the sample from their filing quarter to the earliest of the first quarter after the last notice of allowance or their disposal quarter. The outcome is constructed using CONs in Panel A, CIPs in Panel B, and DIVs in Panel C. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A15: Continuing applications and notice of allowance, issued patents

Applications	All						Excluded if prosecution reopened					
Time periods	All		Up to NOA + 2		Up to NOA + 1		All		Up to NOA + 2		Up to NOA + 1	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: CONs												
NOA	4.29***	3.99***	4.33***	4.00***	4.40***	4.06***	4.29***	4.01***	4.35***	4.04***	4.47***	4.13***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,189,353	35,189,313	34,251,943	34,251,898	33,746,889	33,746,850	33,634,406	33,634,367	32,797,251	32,797,207
R^2	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12
Applications	2,657,501	2,657,490	2,657,501	2,657,490	2,657,501	2,657,490	2,551,059	2,551,049	2,551,059	2,551,049	2,551,059	2,551,049
Mean outcome	0.89	0.89	0.87	0.87	0.78	0.78	0.87	0.87	0.86	0.86	0.79	0.79
Panel B: CIPs												
NOA	0.28***	0.34***	0.28***	0.34***	0.27***	0.33***	0.29***	0.34***	0.29***	0.35***	0.28***	0.34***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,189,353	35,189,313	34,251,943	34,251,898	33,746,889	33,746,850	33,634,406	33,634,367	32,797,251	32,797,207
R^2	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13
Applications	2,657,501	2,657,490	2,657,501	2,657,490	2,657,501	2,657,490	2,551,059	2,551,049	2,551,059	2,551,049	2,551,059	2,551,049
Mean outcome	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Panel C: DIVs												
NOA	2.32***	2.25***	2.37***	2.28***	2.54***	2.43***	2.36***	2.28***	2.40***	2.31***	2.58***	2.48***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,189,353	35,189,313	34,251,943	34,251,898	33,746,889	33,746,850	33,634,406	33,634,367	32,797,251	32,797,207
R^2	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10
Applications	2,657,501	2,657,490	2,657,501	2,657,490	2,657,501	2,657,490	2,551,059	2,551,049	2,551,059	2,551,049	2,551,059	2,551,049
Mean outcome	0.52	0.52	0.51	0.51	0.48	0.48	0.51	0.51	0.51	0.51	0.49	0.49

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample is a subsample of the one in Table 3 that contains only applications that are issued before the end of year 2018. We exclude applications whose prosecution is reopened from the sample for columns 7-12. In columns 1-2 and 7-8, applications are retained in the sample from their filing quarter to their issuance quarter. In columns 3-4 and 9-10, applications are retained in the sample from their filing quarter to the earliest of their issuance quarter or the second quarter after the first notice of allowance. In columns 5-6 and 11-12, applications are retained in the sample from their filing quarter to the earliest of their issuance quarter or the first quarter after the first notice of allowance. The outcome is constructed using CONs in Panel A, CIPs in Panel B, and DIVs in Panel C. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A16: Continuing applications and last notice of allowance, issued patents

Applications	All						Excluded if prosecution reopened					
Time periods	All		Up to NOA + 2		Up to NOA + 1		All		Up to NOA + 2		Up to NOA + 1	
Model	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE	Baseline	TWFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: CONs												
NOA	4.38***	4.07***	4.44***	4.10***	4.56***	4.20***	4.38***	4.07***	4.44***	4.10***	4.56***	4.20***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,361,456	35,361,417	34,485,848	34,485,795	35,479,974	35,479,938	35,360,984	35,360,945	34,485,388	34,485,335
R^2	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12	0.03	0.12
Applications	2,657,501	2,657,490	2,657,494	2,657,480	2,657,488	2,657,464	2,657,469	2,657,458	2,657,462	2,657,448	2,657,456	2,657,432
Mean outcome	0.89	0.89	0.89	0.89	0.82	0.82	0.89	0.89	0.89	0.89	0.82	0.82
Panel B: CIPs												
NOA	0.28***	0.34***	0.28***	0.35***	0.27***	0.34***	0.28***	0.34***	0.28***	0.35***	0.27***	0.34***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,361,456	35,361,417	34,485,848	34,485,795	35,479,974	35,479,938	35,360,984	35,360,945	34,485,388	34,485,335
R^2	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13
Applications	2,657,501	2,657,490	2,657,494	2,657,480	2,657,488	2,657,464	2,657,469	2,657,458	2,657,462	2,657,448	2,657,456	2,657,432
Mean outcome	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Panel C: DIVs												
NOA	2.36***	2.27***	2.40***	2.30***	2.58***	2.47***	2.36***	2.27***	2.40***	2.30***	2.58***	2.47***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Application FE		✓		✓		✓		✓		✓		✓
Age by quarter FE		✓		✓		✓		✓		✓		✓
Observations	35,480,458	35,480,422	35,361,456	35,361,417	34,485,848	34,485,795	35,479,974	35,479,938	35,360,984	35,360,945	34,485,388	34,485,335
R^2	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10
Applications	2,657,501	2,657,490	2,657,494	2,657,480	2,657,488	2,657,464	2,657,469	2,657,458	2,657,462	2,657,448	2,657,456	2,657,432
Mean outcome	0.52	0.52	0.52	0.52	0.50	0.50	0.52	0.52	0.52	0.52	0.50	0.50

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample is a subsample of the one in Table 3 that contains only applications that are issued before the end of year 2018. We exclude applications whose prosecution is reopened from the sample for columns 7-12. In columns 1-2 and 7-8, applications are retained in the sample from their filing quarter to their issuance quarter. In columns 3-4 and 9-10, applications are retained in the sample from their filing quarter to the earliest of their issuance quarter or the second quarter after the last notice of allowance. In columns 5-6 and 11-12, applications are retained in the sample from their filing quarter to the earliest of their issuance quarter or the first quarter after the last notice of allowance. The outcome is constructed using CONs in Panel A, CIPs in Panel B, and DIVs in Panel C. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A17: Continuing applications and office actions, random sample

Outcome	CON × 100		CIP × 100		DIV × 100	
Model	Full	Restricted	Full	Restricted	Full	Restricted
	(1)	(2)	(3)	(4)	(5)	(6)
Notice of allowance	4.06***	4.02***	0.28***	0.27***	2.27***	2.23***
	(0.11)	(0.11)	(0.04)	(0.04)	(0.09)	(0.09)
Final rejection	0.17**		0.12***		0.06	
	(0.07)		(0.04)		(0.06)	
Non-final rejection	-0.08*		0.04		-0.10**	
	(0.05)		(0.03)		(0.04)	
Restriction requirement	0.02		0.08		2.41***	
	(0.07)		(0.05)		(0.09)	
Application FE	✓	✓	✓	✓	✓	✓
Age by quarter FE	✓		✓		✓	
Quarter FE		✓		✓		✓
Observations	298,106	298,275	298,106	298,275	298,106	298,275
R^2	0.13	0.11	0.14	0.13	0.11	0.09
Applications	23,009	23,009	23,009	23,009	23,009	23,009
Mean outcome	0.66	0.66	0.30	0.30	0.37	0.37

Notes. All models are estimated with OLS. The unit of observation is the application-calendar-quarter. The sample contains a 0.5% random sample of the applications in the one in Table 3, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A18: Alternative estimators for two-way fixed effects models

Outcome	CON × 100			CIP × 100			DIV × 100		
Estimator	DCDH	CS	BJS	DCDH	CS	BJS	DCDH	CS	BJS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Notice of allowance	1.32***	3.31***	4.06***	0.07	0.14	0.26***	0.94***	1.02***	2.16***
	(0.12)	(0.25)	(0.11)	(0.06)	(0.11)	(0.04)	(0.10)	(0.13)	(0.08)
Observations	298,644	298,644	298,632	298,644	298,644	298,632	298,644	298,644	298,632
Applications	23,378	23,378	23,373	23,378	23,378	23,373	23,378	23,378	23,373
Mean outcome	0.66	0.66	0.66	0.30	0.30	0.30	0.37	0.37	0.37

Notes. The unit of observation is the application-calendar-quarter. The sample contains a 0.5% random sample of the applications in the one in Table 3, with applications retained in the sample from their filing quarter to the earliest of the disposal quarter or the end of 2018. Columns 1, 4 and 7 are estimated with the estimator proposed by de Chaisemartin and D'Haultfœuille (2020b). Columns 2, 5 and 8 are estimated with the estimator proposed by Callaway and Sant'Anna (2021) using the 'doubly robust' approach and the applications that do not receive a notice of allowance as the control group. Columns 3, 6 and 9 are estimated with the estimator proposed by Borusyak et al. (2021). Standard errors clustered by application in parentheses, with 100 bootstrap repetitions for the de Chaisemartin and D'Haultfœuille (2020a) and Callaway and Sant'Anna (2021) estimators. *** p<0.01, ** p<0.05, * p<0.1.

Table A19: Continuing applications and parent scope narrowing

Outcome	CON × 100 (1)	CIP × 100 (2)	DIV × 100 (3)
Panel A: first independent claim			
Scope narrowing, independent claims	-0.24***	-0.11***	0.65***
	(0.03)	(0.03)	(0.07)
Scope narrowing, words first independent claim	0.24***	0.12***	-0.02
	(0.05)	(0.02)	(0.02)
Observations	1,477,684	1,477,684	1,172,461
R^2	0.08	0.06	0.06
Mean outcome	9.87	3.36	2.25
Panel B: shortest independent claim			
Scope narrowing, independent claims	-0.29***	-0.12***	0.63***
	(0.03)	(0.03)	(0.07)
Scope narrowing, words shortest independent claim	0.22***	0.07***	0.15***
	(0.04)	(0.02)	(0.02)
Observations	1,477,778	1,477,778	1,172,499
R^2	0.08	0.06	0.06
Mean outcome	9.87	3.36	2.25

Notes. All models are estimated with OLS. The unit of observation is the application. The sample contains all the published applications in our main analysis sample with information on the claims that are filed before 2012 and are eventually granted. The sample for column 3 excludes patents that received a restriction requirement prior to the end of 2018. The measures of scope narrowing are standardized. All models include as controls the attributes used in Table 2, as well as filing year and art-unit-by-examiner effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.